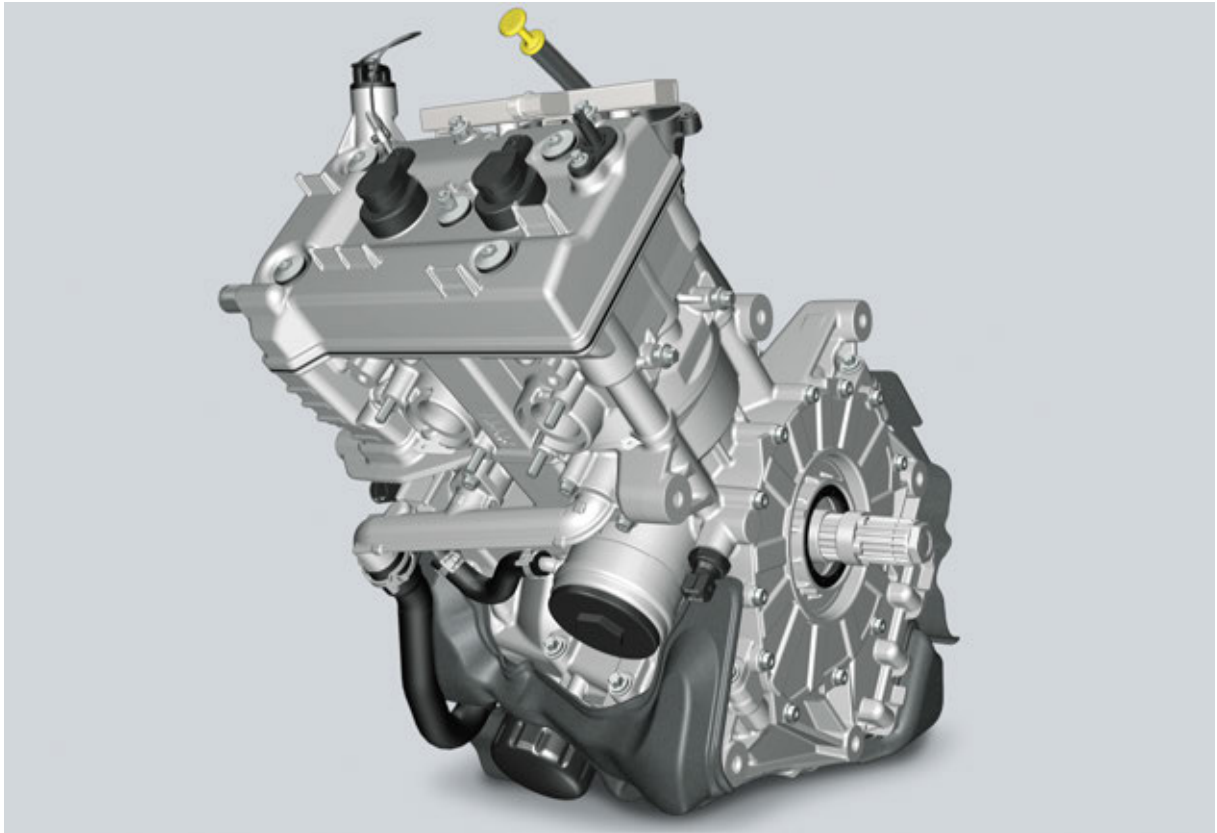


Technical training.
Product information.

W20 Engine



BMW Service

Edited for the U.S. market by:
BMW Group University
Technical Training

ST1403a

2/1/2014

General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:



Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status and national-market versions

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

This document basically relates to the European version of left hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as the result of the equipment specification in specific markets or countries.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

©2013 BMW AG, Munich

Reprints of this publication or its parts require the written approval of BMW AG, Munich

The information contained in this document forms an integral part of the technical training of the BMW Group and is intended for the trainer and participants in the seminar. Refer to the latest relevant information systems of the BMW Group for any changes/additions to the technical data.

Information status: **July 2013**
BV-72/Technical Training

W20 Engine

Contents

1.	Introduction	1
1.1.	Models.....	1
1.2.	Technical data.....	1
1.2.1.	Full load diagram.....	2
1.3.	Overview.....	2
1.4.	Engine identification.....	3
1.4.1.	Engine designation.....	3
1.4.2.	Engine identification.....	4
2.	Engine Mechanics	6
2.1.	Engine housing.....	6
2.1.1.	Crankcase.....	7
2.1.2.	Cylinder head gasket.....	7
2.1.3.	Cylinder head and cover.....	7
2.1.4.	Oil sump.....	8
2.2.	Crankshaft drive.....	9
2.2.1.	Crankshaft with bearings.....	11
2.2.2.	Connecting rod and piston.....	12
2.3.	Counterbalance shafts.....	13
2.3.1.	Crankcase venting components.....	14
2.4.	Camshaft drive.....	16
2.5.	Valve gear.....	18
2.5.1.	Design.....	18
2.5.2.	Camshafts.....	19
3.	Oil Supply	21
3.1.	Hydraulic circuit diagram.....	21
3.2.	Components for the oil supply.....	22
3.3.	Oil pump and pressure control.....	24
3.4.	Engine oil cooling.....	25
3.5.	Oil pressure monitoring.....	25
3.6.	Oil spray nozzles.....	25
4.	Cooling	26
4.1.	System overview.....	26
4.2.	Cooling system.....	27
4.2.1.	Coolant pump.....	30
4.2.2.	Thermostat.....	31
4.3.	Heat management.....	31
4.3.1.	System wiring diagram.....	32
4.3.2.	Temperature monitoring of the engine compartment.....	33

W20 Engine

Contents

5.	Air Intake & Exhaust Emission Systems	34
5.1.	System overview.....	34
5.2.	Air intake system.....	35
5.2.1.	Intake silencer.....	35
5.2.2.	Differentiated air intake system with electronic throttle actuator.....	36
5.3.	Exhaust emission system.....	37
5.3.1.	Structure and function.....	37
6.	Fuel Preparation	39
6.1.	Overview.....	39
6.2.	Fuel pump control.....	40
7.	Fuel Supply	41
7.1.	Installation locations of the components.....	41
7.2.	System overview.....	42
7.3.	Fuel tank.....	44
7.4.	System wiring diagram.....	46
7.5.	Refuelling.....	47
7.6.	Tank leak diagnosis.....	48
8.	Engine Electrical System	49
8.1.	Overview.....	49
8.2.	Engine control unit.....	51
8.2.1.	Overall function.....	52
9.	Operating Strategy in the BMW I01	54
9.1.	Overview.....	54
9.2.	Influencing factors.....	55
9.3.	Automatic engine start/stop function.....	56
9.4.	Automatic service.....	57
10.	Service	58
10.1.	Exhaust-gas test mode.....	58
10.2.	Service Start.....	58
10.3.	Maintenance work.....	59

W20 Engine

1. Introduction

The BMW I01 with eDrive was primarily developed for urban use. The purely electric motor ensures emissions-free mobility and is the modern way of transportation in the city or when commuting. As many customers, do not want to do without a high range, an optional range extender (REX) in the BMW I01 offers the possibility of extending the range. The 2-cylinder engine is a small, very smooth and quiet gasoline engine, which powers a e-machine and delivers the necessary energy to extend the driving range. As a result, the state of charge of the battery can be kept constant so that the vehicle can continue to drive using the electrical machine. As soon as the state of charge of the battery reaches a critical level, the range extender ensures enough energy is available to reach the destination. The range extender is therefore only started by the vehicle electronics if required. In order to realize the lowest possible fuel consumption and reduce CO₂ emissions, the gasoline engine also has an automatic start-stop function and other intelligent operating strategies.

The range extender W20K06U0 is described in this document.

1.1. Models

Development series	Model designation	Engine designation	Series introduction
I01	BMW i3	W20K06U0	03/2014

1.2. Technical data

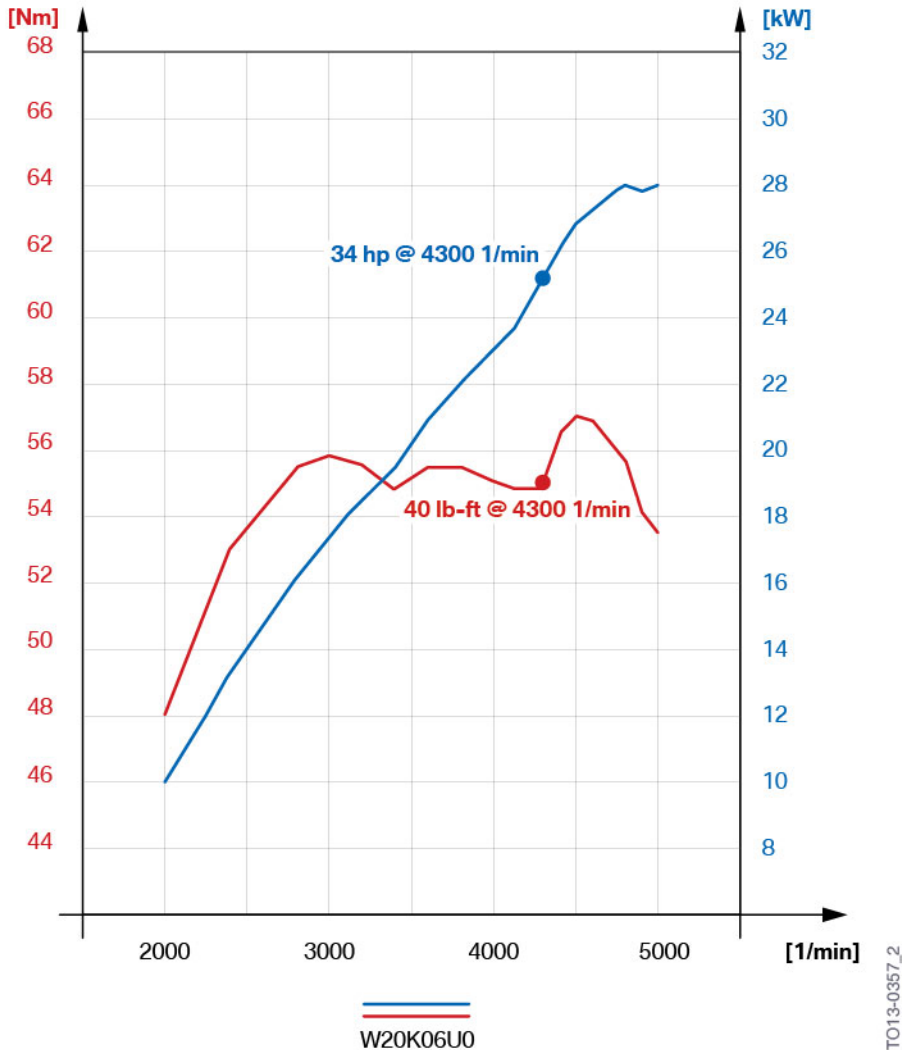
Designation	Unit	W20K06U0
Design		R2
Displacement	[cm ³]	647
Firing order		1-2
Bore/stroke	[mm]	79/66
Power output at engine speed	[kW (HP)] [rpm]	25(34) 4300
Torque at engine speed	[Nm (lb-ft)] [rpm]	55 (40) 4300
Compression ratio	[ε]	10.6
Valves per cylinder		4
Fuel rating	[RON]	95
Fuel	[RON]	87- 98
Exhaust emissions legislation		SULEV II
Additional range in REX driving	[km] (miles)	120-150 (74–90)
Digital Motor Electronics		RDME

W20 Engine

1. Introduction

1.2.1. Full load diagram

W20 engine in the BMW I01



Full load diagram W20K06U0 engine

The operation of the range extender has no influence on the driveability of the vehicle. Only the electrical output power is relevant, which the W20 engine generates by an e-machine. The graphic shows the power data of the combustion engine. Depending on the operating strategy in the BMW I01, a maximum power of 25 kW / 34 hp at a speed of 4300 rpm is used at the time of introduction. The W20 engine powers an e-machine. An efficiency level of approx. 94 % is achieved, which corresponds to a maximum output power of the e-machine of 23.5 kW at a speed of 4300 rpm.

1.3. Overview

The following table provides a technical overview of the W20 engine.

W20 Engine

1. Introduction

System	Comment
Engine mechanics	<ul style="list-style-type: none">• Horizontal crankcase made from die-cast aluminium• Double overhead camshaft cylinder head made from aluminium gravity die casting and water-cooled• One-piece forged crankshaft with two counterbalance shafts• Cast aluminium piston with three piston rings• Valve actuation via bucket tappet by two upper camshafts. Power train via a toothed chain of the crankshaft.
Oil supply	<ul style="list-style-type: none">• Mechanical oil pump, powered via gear stages by a counterbalance shaft• Oil filter elements.
Cooling	<ul style="list-style-type: none">• Mechanical coolant pump• Thermostat-regulated bypass with coolant-to-coolant heat exchanger• Also oil-to-water heat exchanger.
Air intake and exhaust emission systems	<ul style="list-style-type: none">• Intake neck with injector attachment and screw connection for fuel injection pipe, intake pipe fuel injection• Two-piece differentiated air intake system with connections for crankcase ventilation and tank vent valve.
Fuel preparation	<ul style="list-style-type: none">• Return-free fuel system• Fuel injector in differentiated air intake system.
Engine electrical system	<ul style="list-style-type: none">• Range Extender Digital Engine Electronics (RDME)• Engine speed recording via crankshaft sensor wheel.

1.4. Engine identification

1.4.1. Engine designation

The W20 engine in version W20K06U0 is described in this document.

The technical document also contains the short form of the engine designation W20, which only indicates the engine type.

W20 Engine

1. Introduction

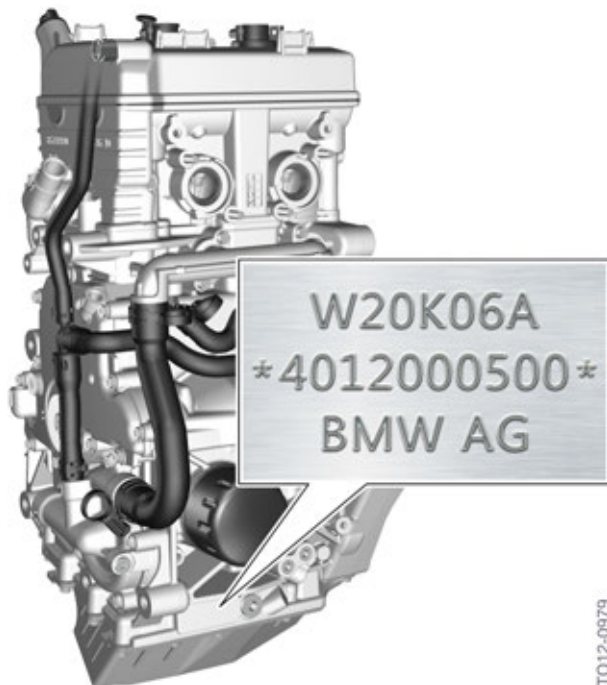
Itemization

Index	Explanation
W	Third-party engine
2	2-cylinder in-line engine
0	Basic engine
K	gasoline installed horizontally
06	0.6 liter displacement
U	Lower performance class
0	New development

1.4.2. Engine identification

The engines have an identification mark on the crankcase to ensure proper identification and classification. This engine identification is necessary for approval by government authorities. The first six positions of the engine identification correspond to the engine designation.

The engine number can be found on the engine below the engine identification. This consecutive number, in conjunction with the engine identification, permits proper identification of each individual engine.



W20 engine, engine identification and engine number

W20 Engine

1. Introduction

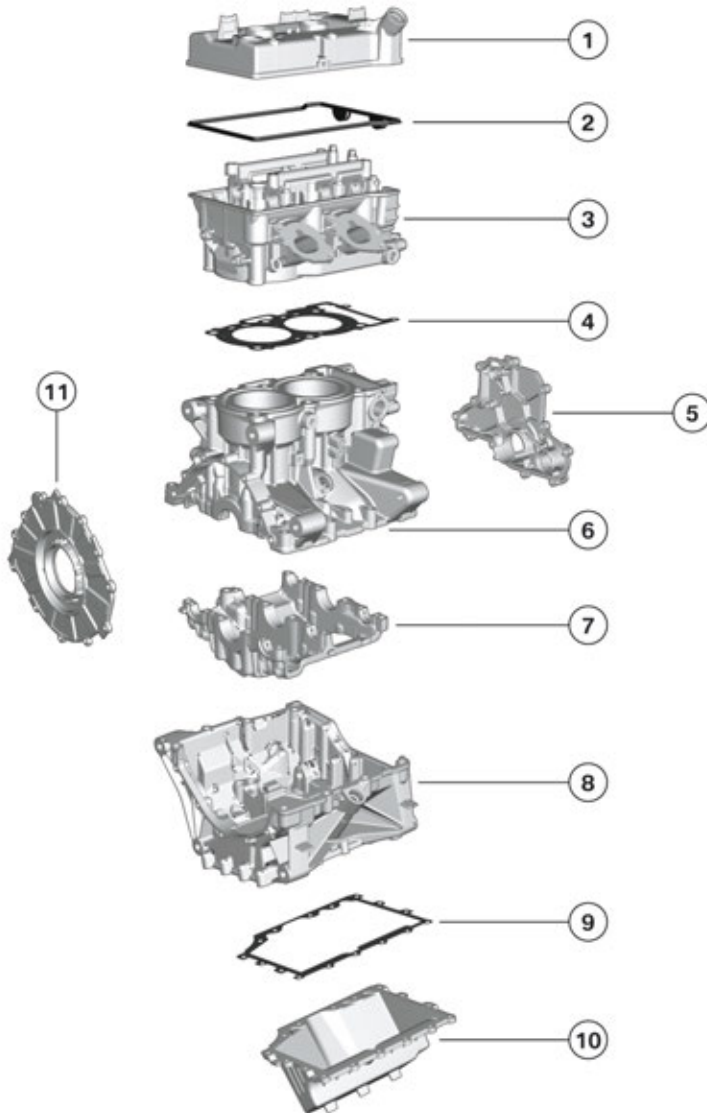
Index	Explanation
W	Third-party engine
2	2-cylinder in-line engine
0	Basic engine
K	gasoline installed horizontally
06	0.6 liter displacement
A	Type test concerns, standard
40	Production week
12	Production year
000500	Consecutive number

W20 Engine

2. Engine Mechanics

2.1. Engine housing

The engine housing comprises the two-piece crankcase, a cylinder head, the cylinder head cover, the oil sump and the gaskets.



TO12-1090

W20 engine, structure of engine housing

Index	Explanation
1	Cylinder head cover
2	Cylinder head cover gasket
3	Cylinder head
4	Cylinder head gasket
5	Timing chain cover
6	Upper crankcase

W20 Engine

2. Engine Mechanics

Index	Explanation
7	Bearing frame
8	Lower crankcase
9	Oil sump gasket
10	Oil sump
11	e-machine cover

2.1.1. Crankcase

The upper crankcase comprises a one-piece compound structure made from die-cast aluminium. The cylinder liners are made from grey cast iron and moulded. The lower crankshaft is connected using liquid seal. This is also made from die-cast aluminium.

2.1.2. Cylinder head gasket

A multilayer spring steel gasket is used for the cylinder head gasket.

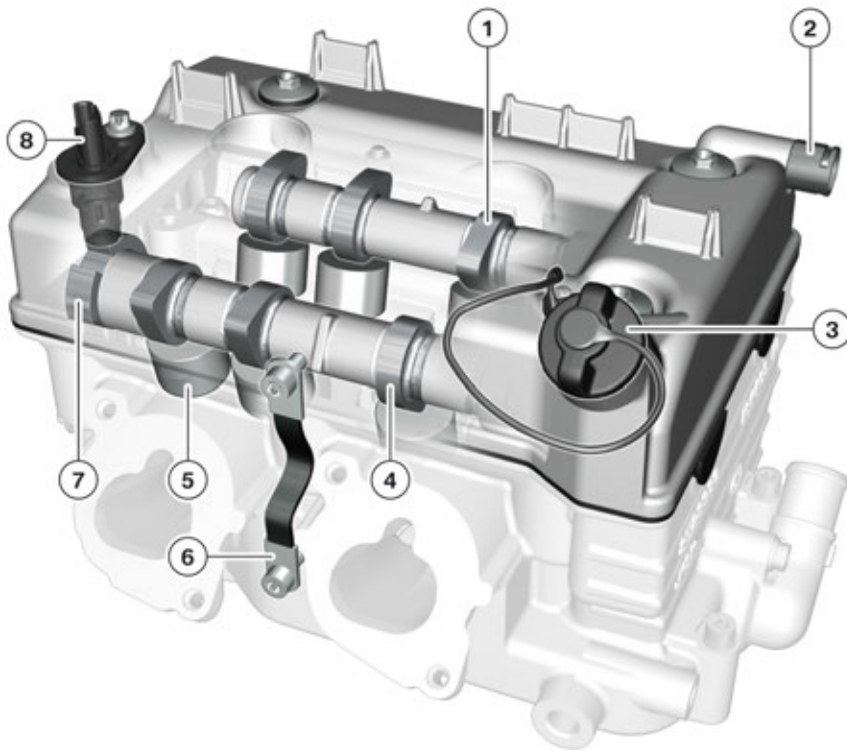
2.1.3. Cylinder head and cover

The cylinder head is made from aluminium gravity die casting and water-cooled. Four valves are positioned in each cylinder, which are actuated via bucket tappet by two upper camshafts.

In the upper area a cylinder head cover with a rubber seal closes the cylinder head at four bolting points. An oil filler neck, the connection for the crankcase ventilation and a camshaft sensor are also integrated here. The cylinder head cover is connected to the cylinder head via a ground strap in order to prevent a static charge.

W20 Engine

2. Engine Mechanics



TO13-0197

W20 engine, cylinder head with cylinder head cover

Index	Explanation
1	Exhaust camshaft
2	Purge air line connection
3	Oil filler neck
4	Intake camshaft
5	Bucket tappet
6	Ground strap
7	Camshaft sensor wheel
8	Camshaft sensor

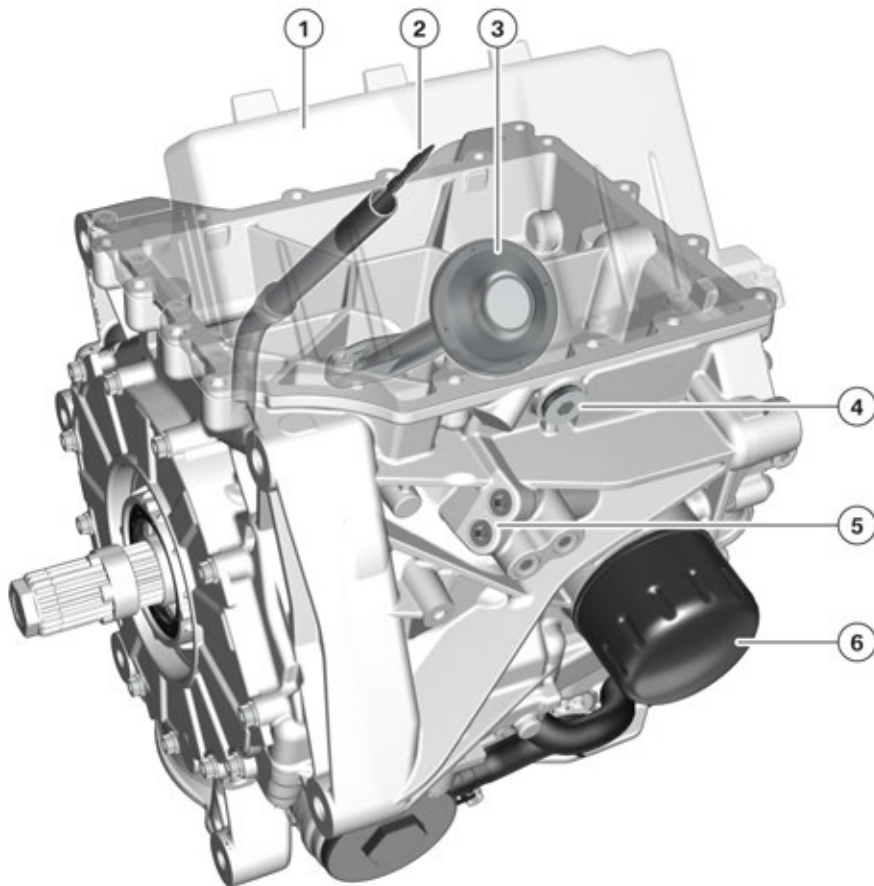
2.1.4. Oil sump

The oil sump is made from aluminium. It is designed as a one-piece component. The pick up tube of the oil pump is positioned deep within the sump. This ensures that the oil supply is guaranteed in every driving situation.

The oil pump itself is screwed to the lower crankcase. The oil level in the oil sump is determined when the engine is at a standstill using an oil dipstick.

W20 Engine

2. Engine Mechanics



TO13-0198

W20 engine, aluminium oil sump

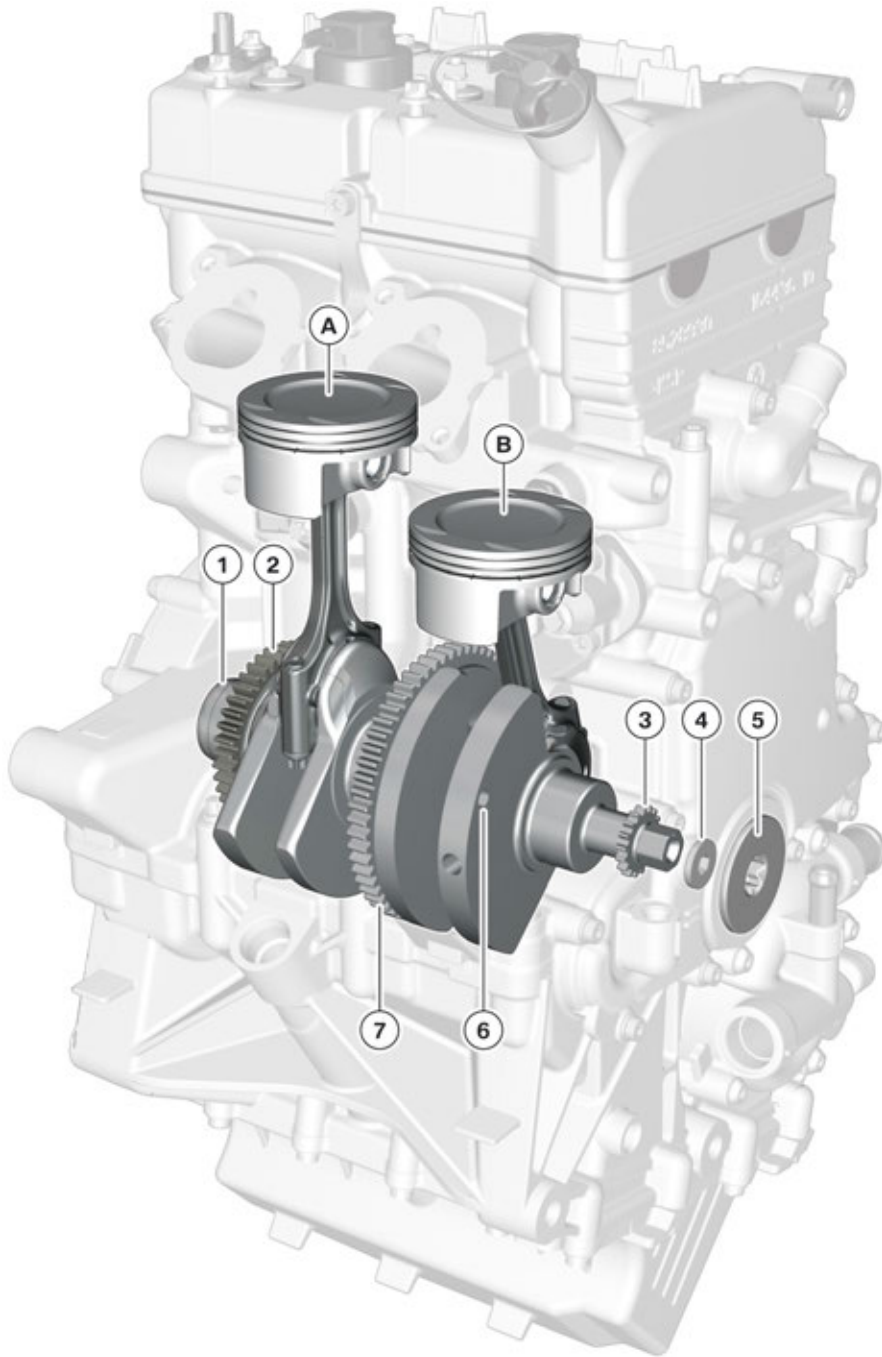
Index	Explanation
1	Oil sump
2	Oil dipstick
3	Pick up tube
4	Oil drain plug
5	Connection for the engine oil cooler
6	Oil filter

2.2. Crankshaft drive

The core of the 2-cylinder in-line engine is a crankshaft with a crankpin offset of 90 degrees. Two counterbalance shafts ensure smooth engine running. They are driven directly by the crankshaft.

W20 Engine

2. Engine Mechanics



TO13-0200

W20 engine, crankshaft drive with connecting rod and piston

Index	Explanation
A	Cylinder 1
B	Cylinder 2
1	Crankshaft, output of e-machine
2	Sprocket, counterbalance shafts

W20 Engine

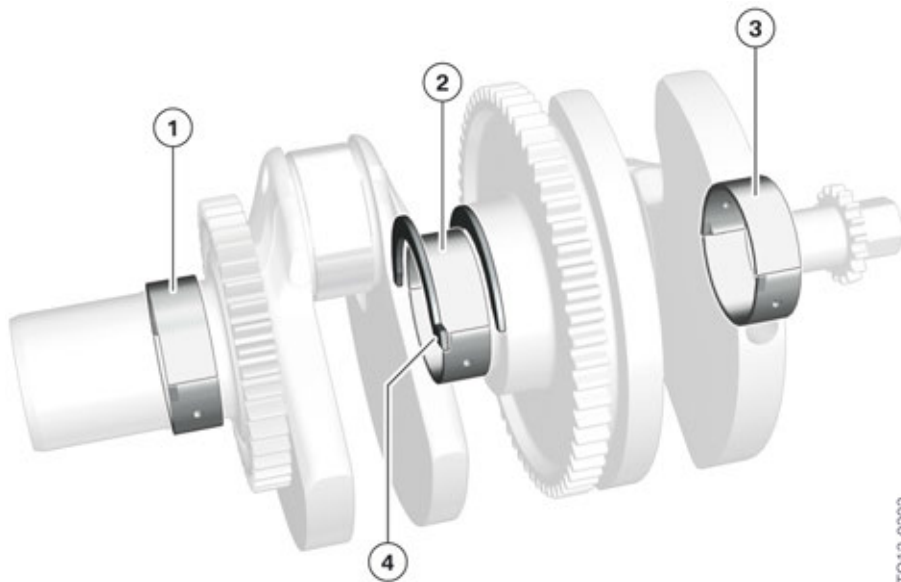
2. Engine Mechanics

Index	Explanation
3	Sprocket, timing chain
4	Screw plug
5	Screw plug
6	Dowel hole
7	Increment wheel

2.2.1. Crankshaft with bearings

Crankshaft

The crankshaft is forged from high-strength steel, has a stroke of 66 mm and is positioned in three bearing positions with lead free multi-component bearings. The diameter of the crank journal corresponds to the diameter of the main bearing and is 42 mm. Two thrust washers for adjusting the end clearance are positioned at the middle main bearing.



W20 engine, crankshaft bearings

Index	Explanation
1	Bearing shells on e-machine side without groove
2	Upper bearing shell with groove, lower bearing shell without groove
3	Bearing shells without groove
4	Thrust washer



The identification markings for the bearings are stamped on the crankcase and on the crankshaft. Refer to the repair instructions if the crankshaft is to be fitted with new bearings.

W20 Engine

2. Engine Mechanics

Bearing frame

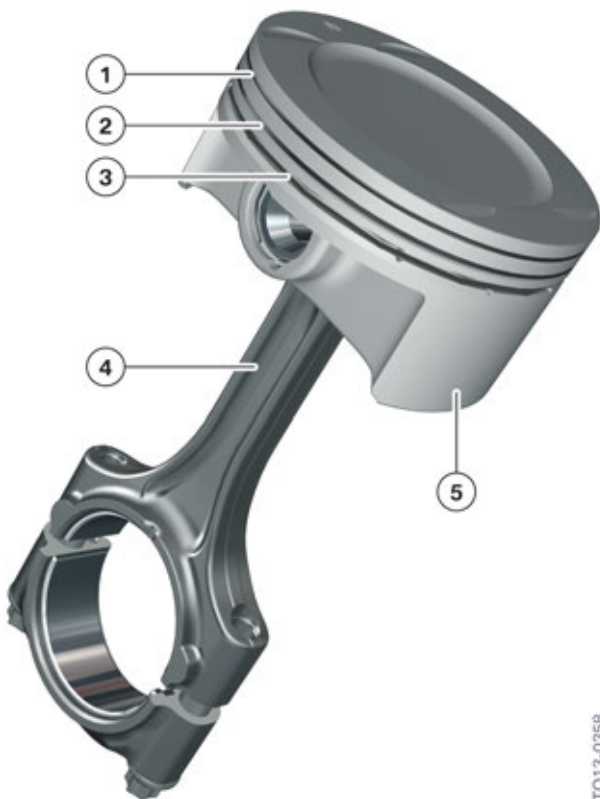
The upper crankcase and a bearing frame hold the crankshaft bearing shells and the bearing shells of the counterbalance shafts. Both components are screwed together at several attachment points.

Torsion shaft

The crankshaft is force-fitted to the range extender electrical machine via a tensioned torsion shaft.

2.2.2. Connecting rod and piston

The 113 mm long connecting rods are forged from steel. The connecting rod is split at the 42 mm bearing position and milled smooth. In addition to mounting with connecting rod bolts, cylindrical pins are used for centering. The connecting rod bearing shells are designed as lead-free multi-component slide bearings. The small connecting rod eye has a brass bushing for mounting the 18 mm wrist pin. The light metal box pistons are cast and only weigh 200 g. The wrist pins are offset by 0.8 mm.



W20 engine, piston with connecting rod

TO13-0358

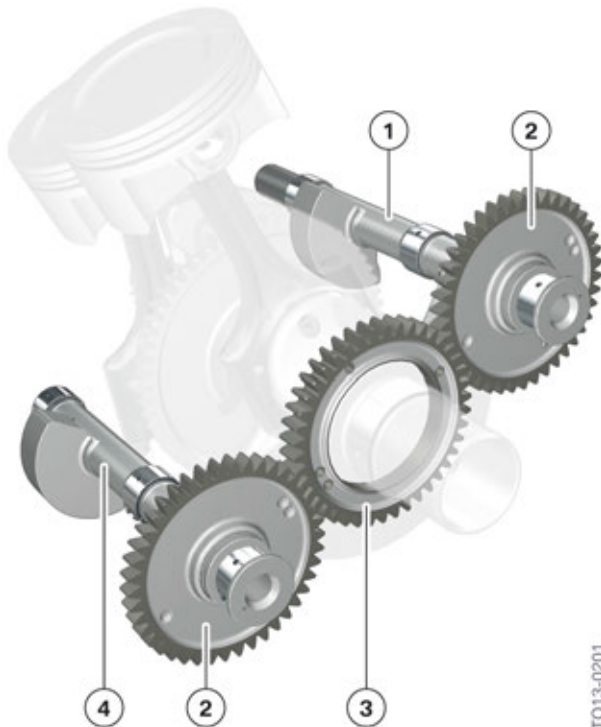
W20 Engine

2. Engine Mechanics

Index	Explanation
1	Plain rectangular compression ring with a spherical design
2	Stepped compression ring
3	3-piece oil scraper ring with spring
4	Connecting rod with connecting rod cap
5	Light metal box piston

2.3. Counterbalance shafts

The compensation of the inertia forces and torques exerted which arise through the rotating and oscillating movements of the crankshaft drive is realized for this design by two additional counterbalance shafts. For smooth and vibration-free engine running, the crankshaft on the e-machine side drives two counterbalance shafts via spur gears. Both counterbalance shafts have two counterweights offset by 90°. These rotate at the same speed as the crankshaft, but in the opposite direction. This arrangement of the mass balance functions with very low friction losses, which in turn benefits the efficiency of the engine.



W20 engine, counterbalance shafts

TO13-0201

W20 Engine

2. Engine Mechanics

Index	Explanation
1	Upper counterbalance shaft
2	Spur gears with marks
3	Sprocket with marks
4	Lower counterbalance shaft



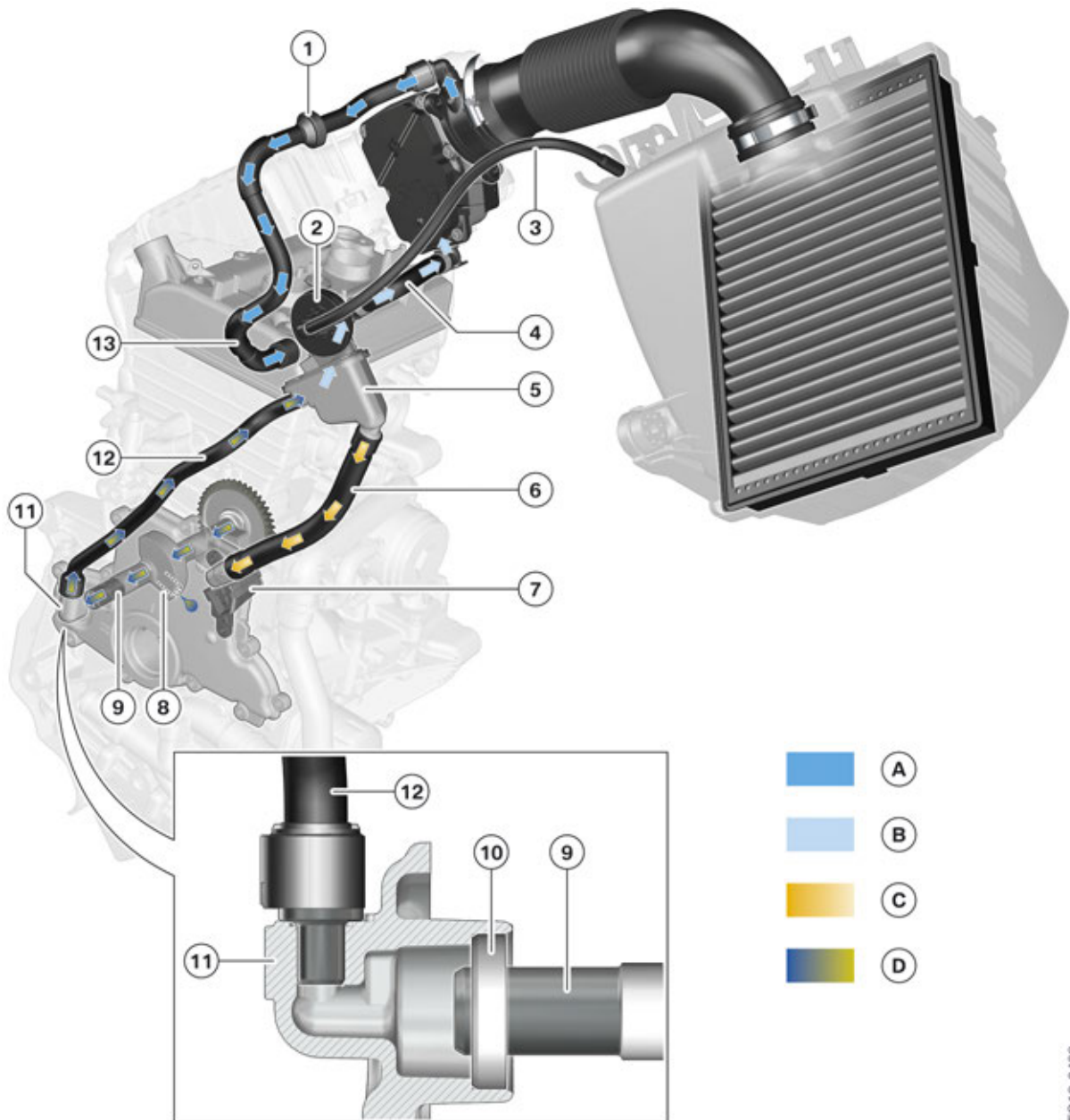
The identifications on the sprocket and the spur gears of the counterbalance shafts are used for the correct assignment during installation. The repair instructions must be followed.

2.3.1. Crankcase venting components

The blow-by gases arising during the combustion cycle make it into the crankcase between piston rings and cylinder wall. These cannot be released into the atmosphere. For this reason the gases from the crankcases are fed back to the combustion chamber via the differentiated air intake system. Oil particles in the blow-by gases are separated beforehand and fed back to the oil sump. The cleaned blow-by gases then make it to the differentiated air intake system. The following graphic shows the layout and the operating principle of the crankcase ventilation.

W20 Engine

2. Engine Mechanics



W20 engine, crankcase ventilation

TO13-0409

Index	Explanation
A	Scavenging air
B	Blow-by gases (cleaned)
C	Motor oil
D	Blow-by gases
1	Non-return valve
2	Pressure control valve

W20 Engine

2. Engine Mechanics

Index	Explanation
3	Hose (US version)
4	Intake pipe
5	Oil separator
6	Return line
7	Non-return valve
8	Vent hole
9	Counterbalance shaft
10	Radial shaft seal
11	Hose connection
12	Intake pipe
13	Purge air line

Operating principle

The blow-by gases are guided through the upper counterbalance shaft (9). The first separation of the oil particles take place via a radial vent hole (8) by the balance weight. Through the rotational movement of the shaft and the resulting centrifugal force oil particles are fed back to the crankcase via the vent hole (8). The blow-by gases now go from the counterbalance shaft directly to the oil separator (5) via the intake pipe (12). The oil particles are collected here and flow back into the engine via the return line (6) by the non-return valve (7). The cleaned blow-by gas in the oil separator is guided through the intake pipe (4) via the pressure control valve (2) to the differentiated air intake system. The throttle valve is adjusted so that a vacuum is available in the differentiated air intake system. The pressure control valve (2) adjusts a vacuum of maximum 60 mbar in the crankcase.

Through the arising vacuum in the crankcase fresh air is drawn in to the crankcase via a purge air line (13) with non-return valve (1) directly via the cylinder head cover. The combustion engine is therefore flushed with fresh air.

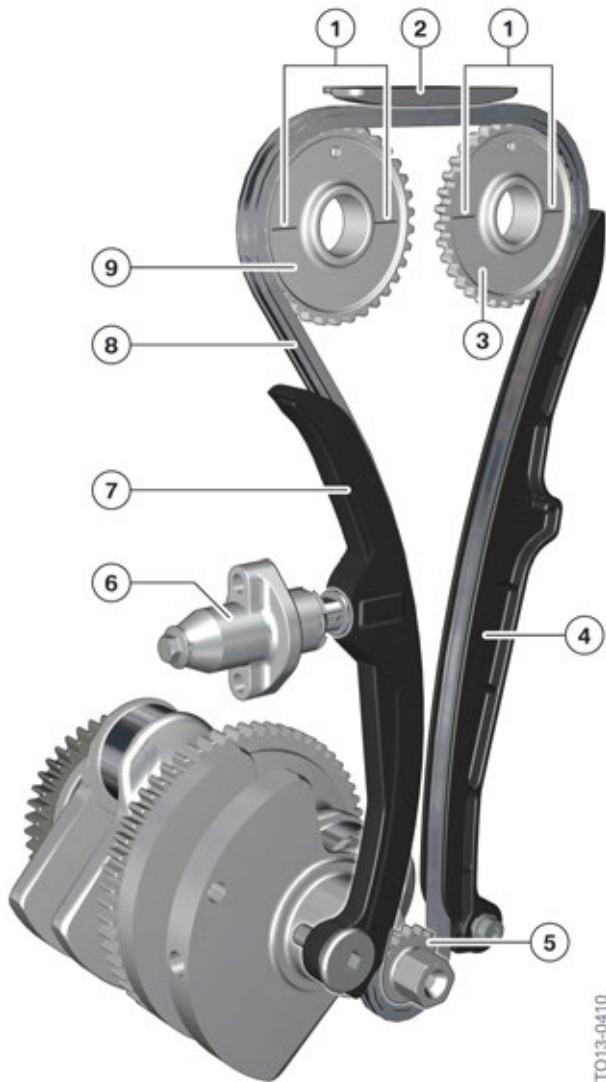
2.4. Camshaft drive

The pressed camshaft sprockets of the camshafts are driven via a toothed chain by a small gear on the crankshaft. The chain is guided without play around the camshaft sprockets with a guide and tensioning rail and a spring-loaded, maintenance-free chain tensioner.

The piston of the chain tensioner is pressed at the tensioning rail using a torsion spring. The thrust piece automatically drives outwards via a thread in the event of a stretched timing chain. With this design the thrust piece can no longer move back independently.

W20 Engine

2. Engine Mechanics



W20 engine, camshaft drive

Index	Explanation
1	Marks as fitting aid
2	Chain guide, upper
3	Camshaft sprocket of exhaust camshaft
4	Guide rail
5	Sprocket
6	Chain tensioner
7	Tensioning rail
8	Toothed chain with 128 links
9	Intake camshaft sprocket

W20 Engine

2. Engine Mechanics

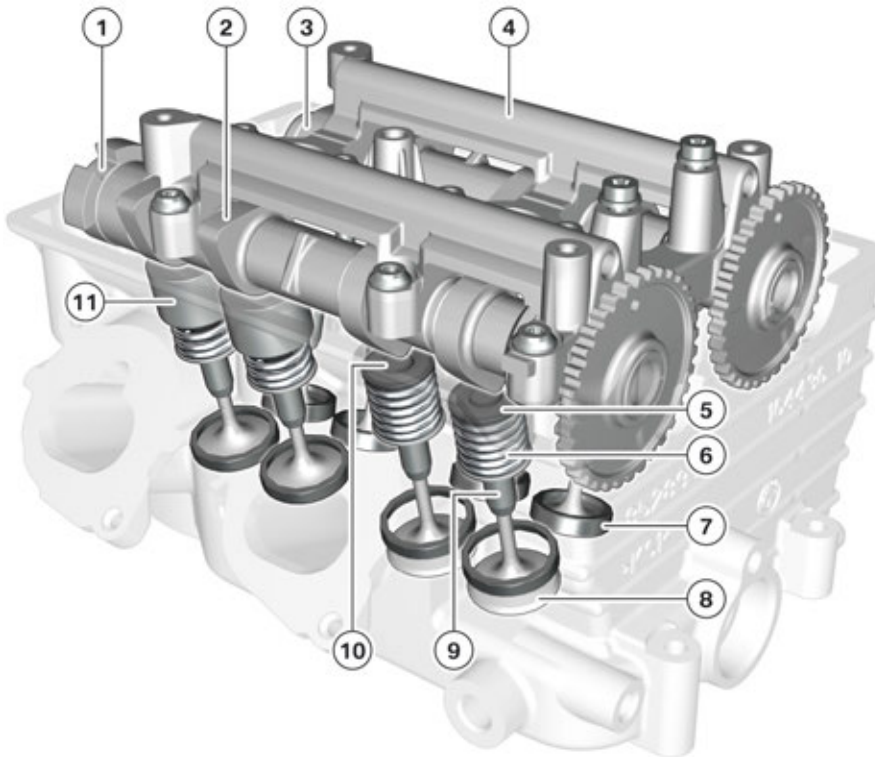


The chain tensioner can only be disassembled and installed using the corresponding special tool. The repair instructions must be followed.

2.5. Valve gear

2.5.1. Design

The eight valves are actuated by the cams directly via a bucket tappet with a diameter of 28 mm. The valve clearance is set correctly during the plant installation of the engine by adjustment plates, which sit in the valve spring retainer under the bucket tappets. The valves are designed with a shaft diameter of 5 mm, have different valve diameters on the intake and exhaust side and are designed in valve guides made from sintered metal. Eight similar valve springs ensure the valves close. The valve angle of 12° at the intake and 14° at the exhaust valves create a compact combustion chamber and good flow conditions for the gas exchange and thus have extremely efficient combustion processes.



TO13-0411

W20 engine, layout of the valve gear

Index	Explanation
1	Camshaft sensor wheel
2	Intake camshaft
3	Exhaust camshaft
4	Bearing bracket

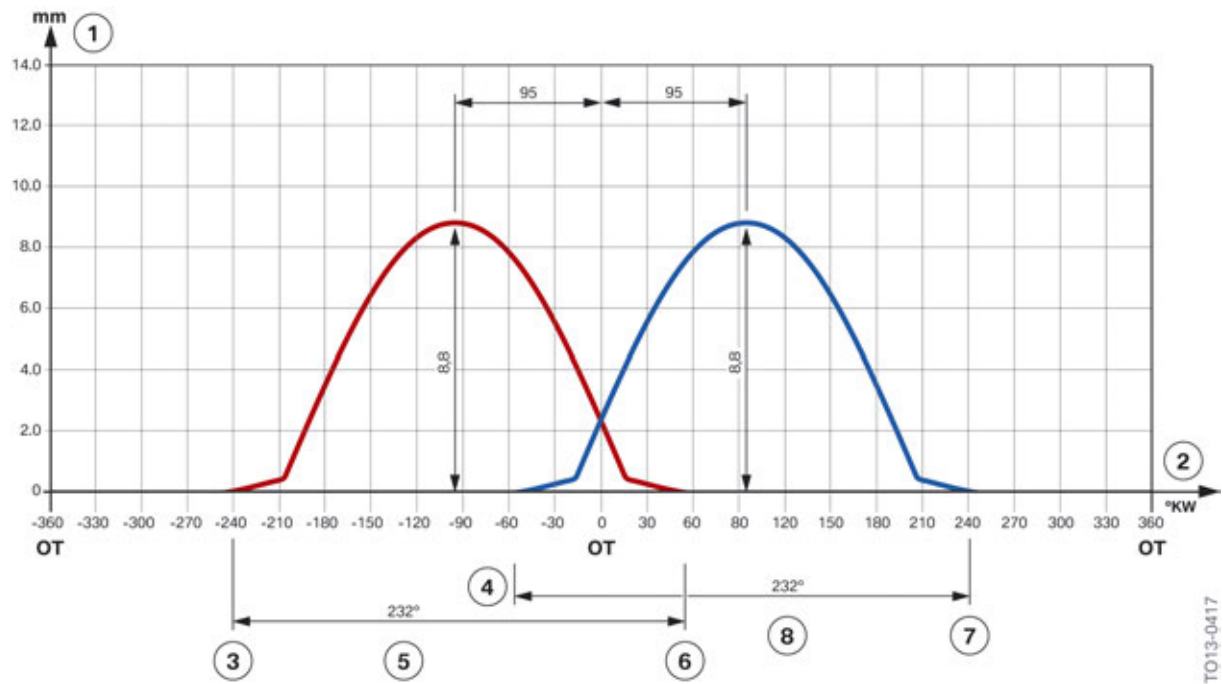
W20 Engine

2. Engine Mechanics

Index	Explanation
5	Valve spring cap
6	Valve spring
7	Valve seat insert
8	Intake valve
9	Valve guide
10	Adjustment plate
11	Bucket tappet

2.5.2. Camshafts

In the valve gear hollowed camshafts are used for actuating the bucket tappet. A bearing bracket positions both camshafts in the bearing positions of the cylinder head. The following graphic provides an overview of the timing diagram and shows a table with technical data.



W20 engine, timing diagram

Index	Explanation
1	Valve lift [mm]
2	Crankshaft degrees [°KW]
3	Exhaust valve open
4	Intake valve open

W20 Engine

2. Engine Mechanics

Index	Explanation
5	Opening period of exhaust valve
6	Exhaust valve closes
7	Intake valve closes
8	Opening period, intake valve [°KW]

Technical data of valve gear

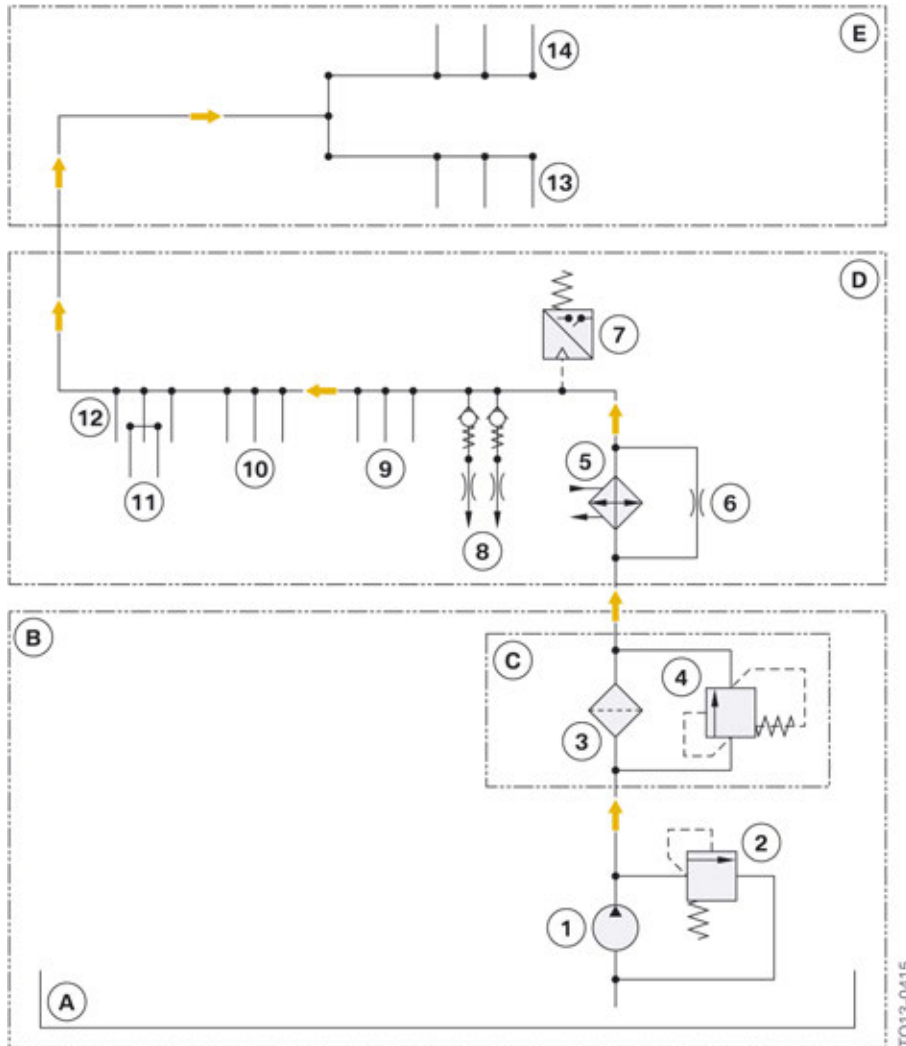
	Unit	Intake camshaft	Exhaust camshaft
Valve clearance	[mm]	0.16 - 0.24	0.24 - 0.32
Valve diameter	[mm]	31.5	27.1
Shaft diameter	[mm]	5	5
Valve lift	[mm]	8.8	8.8
Spread	[crankshaft degrees]	95	95
Opening period	[crankshaft degrees]	232	232

W20 Engine

3. Oil Supply

3.1. Hydraulic circuit diagram

The following graphic provides an initial overview of the oil supply.



W20 engine, hydraulic circuit diagram

Index	Explanation
A	Oil sump
B	Lower crankcase
C	Oil filter housing
D	Upper crankcase with bearing frame
E	Cylinder head
1	Oil pump
2	Pressure-limiting valve
3	Oil filter

W20 Engine

3. Oil Supply

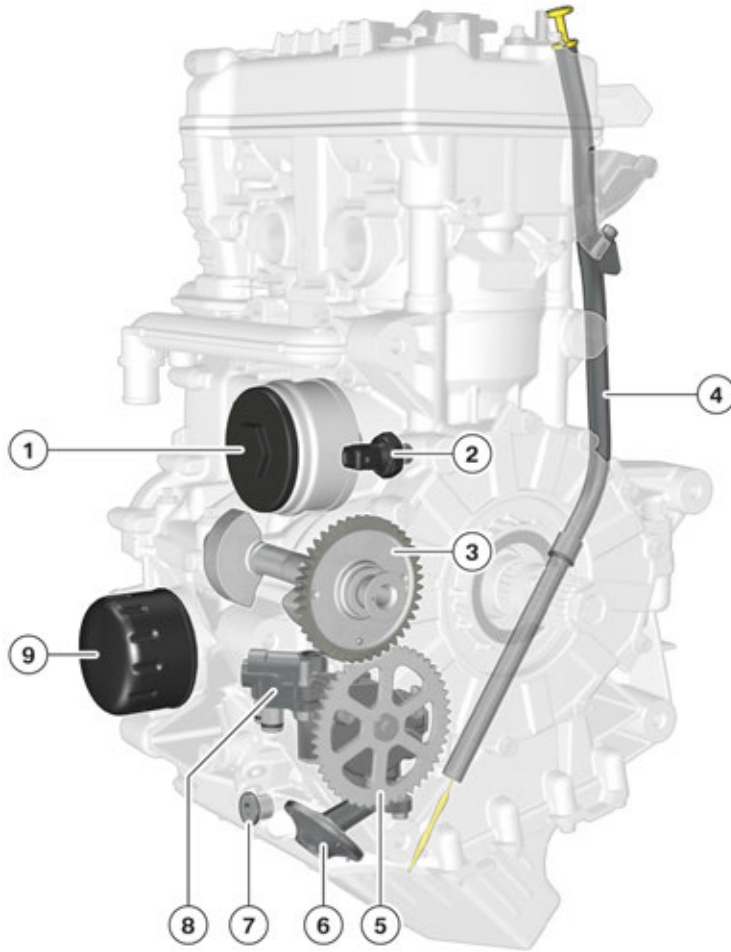
Index	Explanation
4	Filter bypass valve
5	Engine oil-to-coolant heat exchanger
6	Permanent bypass
7	Oil pressure switch
8	Oil spray nozzles for piston crown cooling
9	Lubrication points, first counterbalance shaft
10	Lubrication points, second counterbalance shaft
11	Lubrication points, connecting rod bearing above the crankshaft main bearing
12	Lubrication points, crankshaft main bearings
13	Lubrication points on intake camshaft
14	Lubrication points on exhaust camshaft

3.2. Components for the oil supply

The oil pump draws in the oil from the oil sump below via the pick up tube and delivers it via the oil filter and the engine oil-coolant heat exchanger to the bearing positions in the engine and cylinder head. The lower counterbalance shaft is driven via the crankshaft and is tightly connected to the oil pump drive by a gear.

W20 Engine

3. Oil Supply



TO13-0418

W20 engine, components for the oil supply

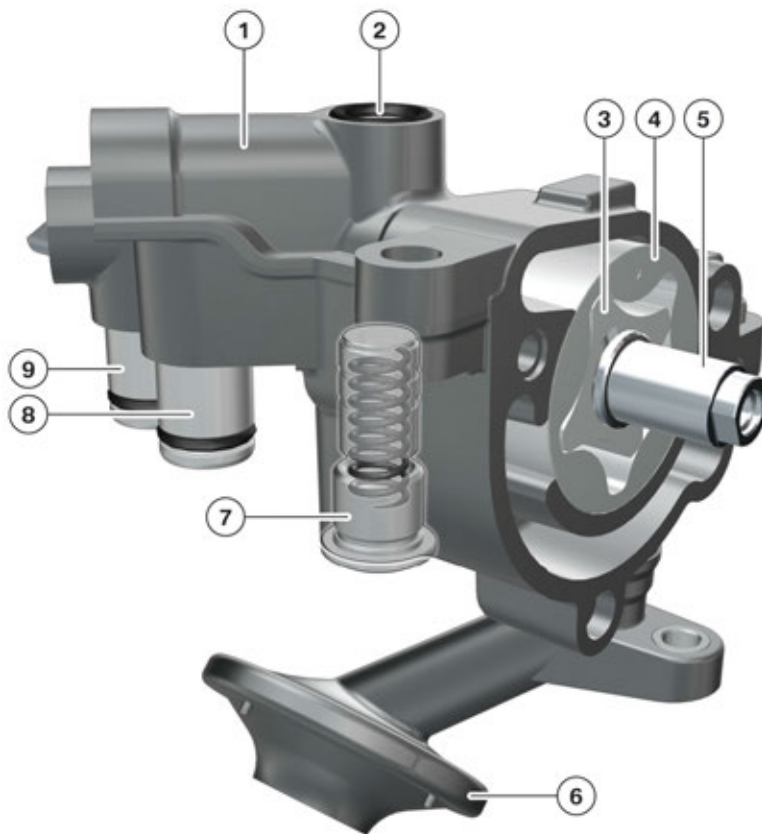
Index	Explanation
1	Oil-to-water heat exchanger
2	Oil pressure switch
3	Sprocket of counterbalance shaft
4	Oil dipstick
5	Sprocket of oil pump
6	Pick up tube
7	Oil drain plug
8	Oil pump
9	Oil filter

W20 Engine

3. Oil Supply

3.3. Oil pump and pressure control

The oil pump is designed as a rotor pump. The ring-shaped operating chamber holds an outer rotor with inner teeth and an inner rotor with outer teeth. These can be rotated in the operating chamber so that the inner and outer teeth interlock. The drive shaft is firmly connected to the inner rotor. With the rotational movement the spaces between the outer and inner rotor are permanently reduced and enlarged. As a result, on the one hand the engine oil is drawn in via the oil pump filter and, on the other hand, the engine oil is compressed and delivered to the engine oil-coolant heat exchanger in the output duct. In the oil pump housing a control valve is installed with an opening pressure of approx. 5.2 bar. The oil pump is powered via a pair of gears by the lower counterbalance shaft.



TO13-0416

W20 engine, oil pump

Index	Explanation
1	Oil pump housing
2	Output for oil duct in the bearing frame
3	Inner rotor with outer teeth
4	Outer rotor with inner teeth
5	Drive shaft

W20 Engine

3. Oil Supply

Index	Explanation
6	Pick up tube
7	Pressure-limiting valve
8	Inlet, engine oil-to-coolant heat exchanger
9	Oil filter inlet

3.4. Engine oil cooling

The W20 engine has an oil-to-water heat exchanger for cooling the engine oil which is attached on the outlet side in the upper crankcase. Before the oil reaches the lubrication points in the engine, it is fed through the heat exchanger. This has two advantages: In the cold-start phase, on the one hand through the quick increase of the coolant temperature the engine oil is brought quicker to operating temperature. On the other hand, the engine oil is cooled if the coolant temperature is lower than the engine oil temperature.

3.5. Oil pressure monitoring

In addition to the oil-to-water heat exchanger, the oil pressure switch is also located in the upper crankcase. This is used for monitoring the oil pressure and issues a signal to the engine control unit if the pressure falls below 0.5 bar.

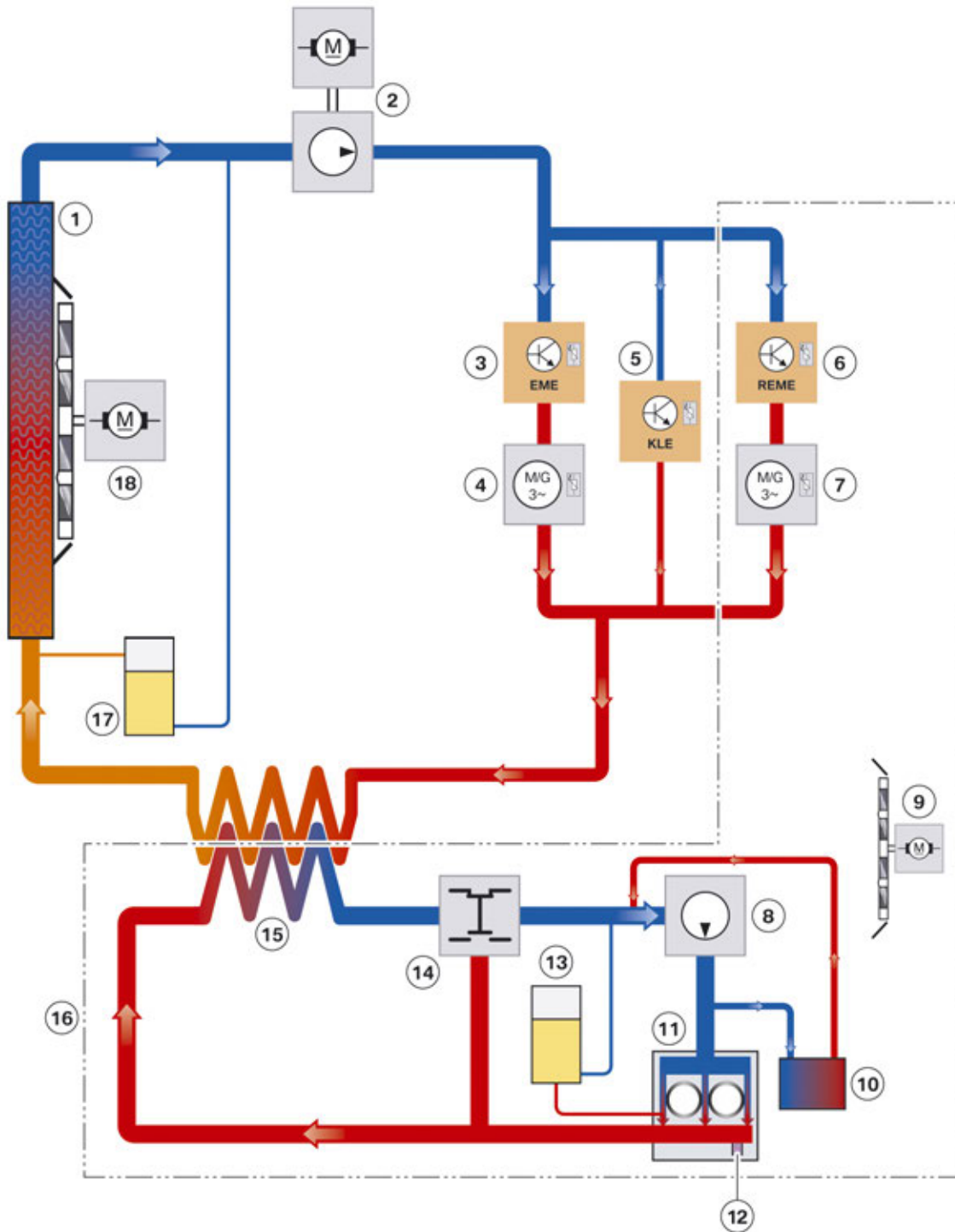
3.6. Oil spray nozzles

In the W20 engine, some of the components which cannot be reached directly by an oil duct are lubricated and cooled by oil spray nozzles. The piston crown and gudgeon pin are permanently sprayed and cooled via two oil spray nozzles in the upper crankcase. A non-return valve is integrated here, which only opens from an oil pressure of approx. 2.3 bar. Each cylinder has its own oil spray nozzle, which obtains the correct installation position through its styling.

W20 Engine

4. Cooling

4.1. System overview



BMW I01, cooling circuit, with range extender

TO12-1020

W20 Engine

4. Cooling

Index	Explanation
1	Radiator
2	Electric coolant pump 80 W
3	Electrical machine electronics (EME)
4	Electrical machine
5	Convenience charging electronics (KLE)
6	Range Extender Electrical Machine Electronics (REME)
7	Electrical machine for REX
8	Mechanical coolant pump
9	Additional electric fan
10	Engine oil-to-coolant heat exchanger
11	Combustion engine W20
12	Coolant temperature sensor
13	Expansion tank
14	Thermostat
15	Coolant-to-coolant heat exchanger
16	Equipment only with range extender
17	Expansion tank
18	Electric fan

As a purely electric vehicle without range extender, the BMW i01 has a cooling circuit for the high-voltage components. If a range extender is installed, then the necessary cooling of the combustion engine is done by a second cooling circuit. The entire cooling system of the BMW i01 is shown in the graphic. In the following details are provided on the cooling circuit of the W20 engine. Information on the cooling circuit of the high-voltage system can be found in the training reference manual "i01 High-voltage Components".

4.2. Cooling system

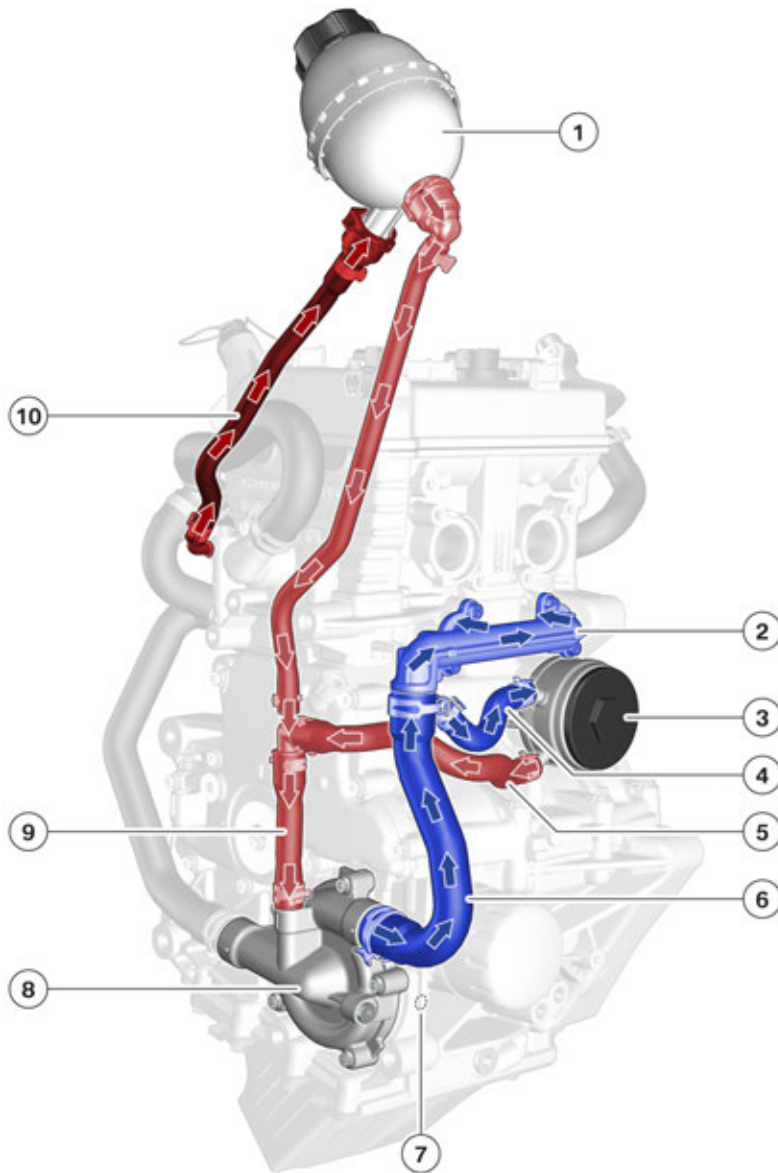
The recirculation of the coolant is guaranteed using a conventional coolant pump and the control of the cooling system using a thermostat wax element. The engine is washed with the coolant according to the cross flow concept. An engine oil-to-coolant heat exchanger (3) is connected in parallel in the coolant feed line. This ensures that in the event of a very high speed of the combustion engine the engine oil temperature does not become too high. The expansion tank (1) only has a minimum and maximum mark to control the level. The pressure relief valve in the sealing cap of the expansion tank opens from 1.4 bar. The following graphics show the installation locations and layout of the components with the direction of flow of the coolant.



If oil or coolant emerges from the leakage bore hole (7), this indicates a leaking radial shaft seal. The repair instructions must be followed.

W20 Engine

4. Cooling



TO13-0471

W20 engine, cooling circuit, coolant pump outlet

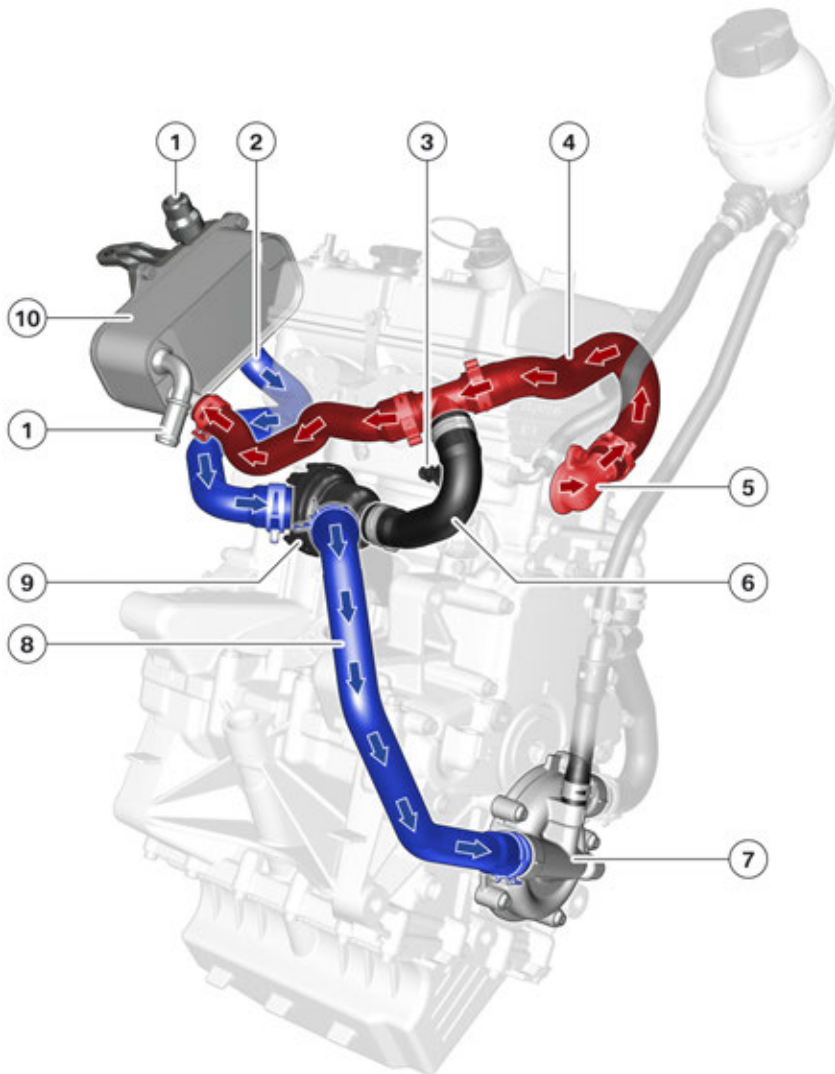
Index	Explanation
1	Expansion tank
2	Water inlet pipe
3	Engine oil-to-coolant heat exchanger
4	Coolant hose (inlet)
5	Coolant hose (reverse)
6	Coolant hose (inlet)

W20 Engine

4. Cooling

Index	Explanation
7	Weep hole
8	Coolant pump housing with oil drain plug
9	Coolant hose (reverse)
10	Coolant hose (inlet)

The cooling circuit of the W20 engine is connected to the cooling circuit of the high-voltage components via a coolant-to-coolant heat exchanger (10). A thermostat (9) integrates the heat exchanger from a coolant temperature of 85° C in the cooling circuit and is completely opened from 95° C. In the following graphic the direction of flow of the coolant is shown when the thermostat is open. If the thermostat is closed, the coolant flows back to the coolant pump via the coolant hose (6). The coolant-to-coolant heat exchanger is therefore not integrated at a coolant temperature below 85° C.



TO13-0472

W20 engine, cooling circuit, coolant pump inlet

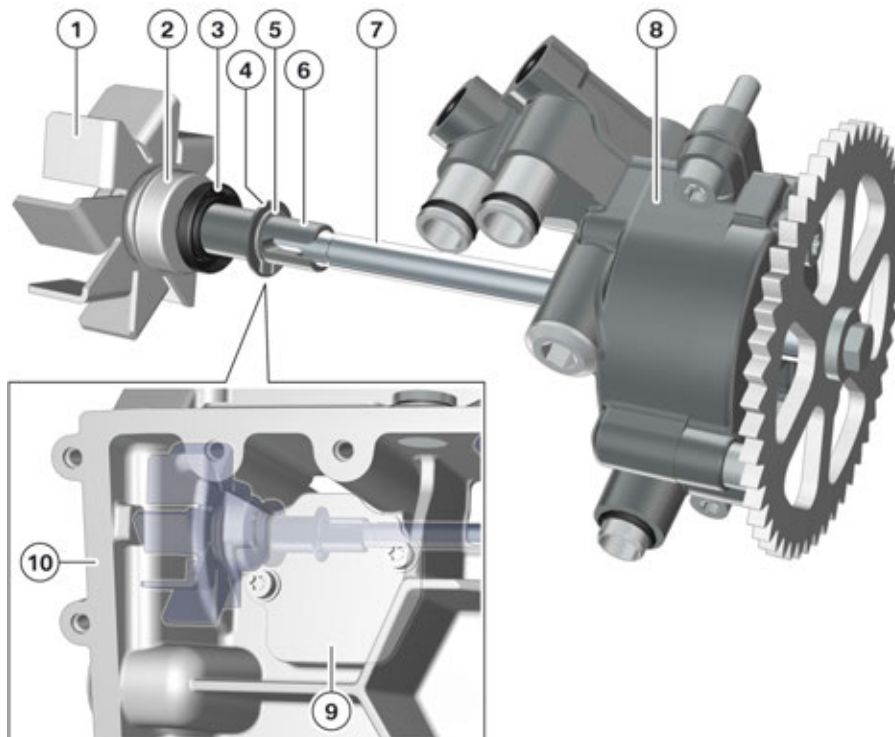
W20 Engine

4. Cooling

Index	Explanation
1	Connections, cooling circuit of electric drive
2	Output, coolant-to-coolant heat exchanger
3	Coolant temperature sensor
4	Coolant hose
5	Coolant outlet
6	Coolant hose
7	Housing of coolant pump
8	Heater return hose
9	Thermostat with wax element
10	Coolant-to-coolant heat exchanger

4.2.1. Coolant pump

The purely mechanical coolant pump forms one unit with the coolant pump wheel and the shaft. This is force-fitted to the oil pump shaft (7). In the event of a leak in the radial shaft seals the water pump wheel with shaft must be removed. In order to access the circlip (5), the oil sump and the panel (9) secured with two screws in the lower crankcase (10) must be disassembled.



W20 engine, coolant pump

TO13-0483

W20 Engine

4. Cooling

Index	Explanation
1	Coolant pump wheel
2	Mechanical seal
3	Radial shaft seal
4	Disc
5	Circlip
6	Coolant pump shaft
7	Oil pump shaft
8	Oil pump
9	Panel
10	Lower crankcase

4.2.2. Thermostat

Coolant is always flowing in the expansion element in the inside of the thermostat. At a coolant temperature of 85° C the thermostat begins to open and completely clears the way via the coolant-to-coolant heat exchanger from 95° C.

4.3. Heat management

The cooling of the W20 engine is regulated via the mechanical coolant pump, the coolant-to-coolant heat exchanger and the thermostat. The delivery rate and also the flow rate through the coolant pump are solely defined by the speed of the crankshaft. There is no electrical control here.

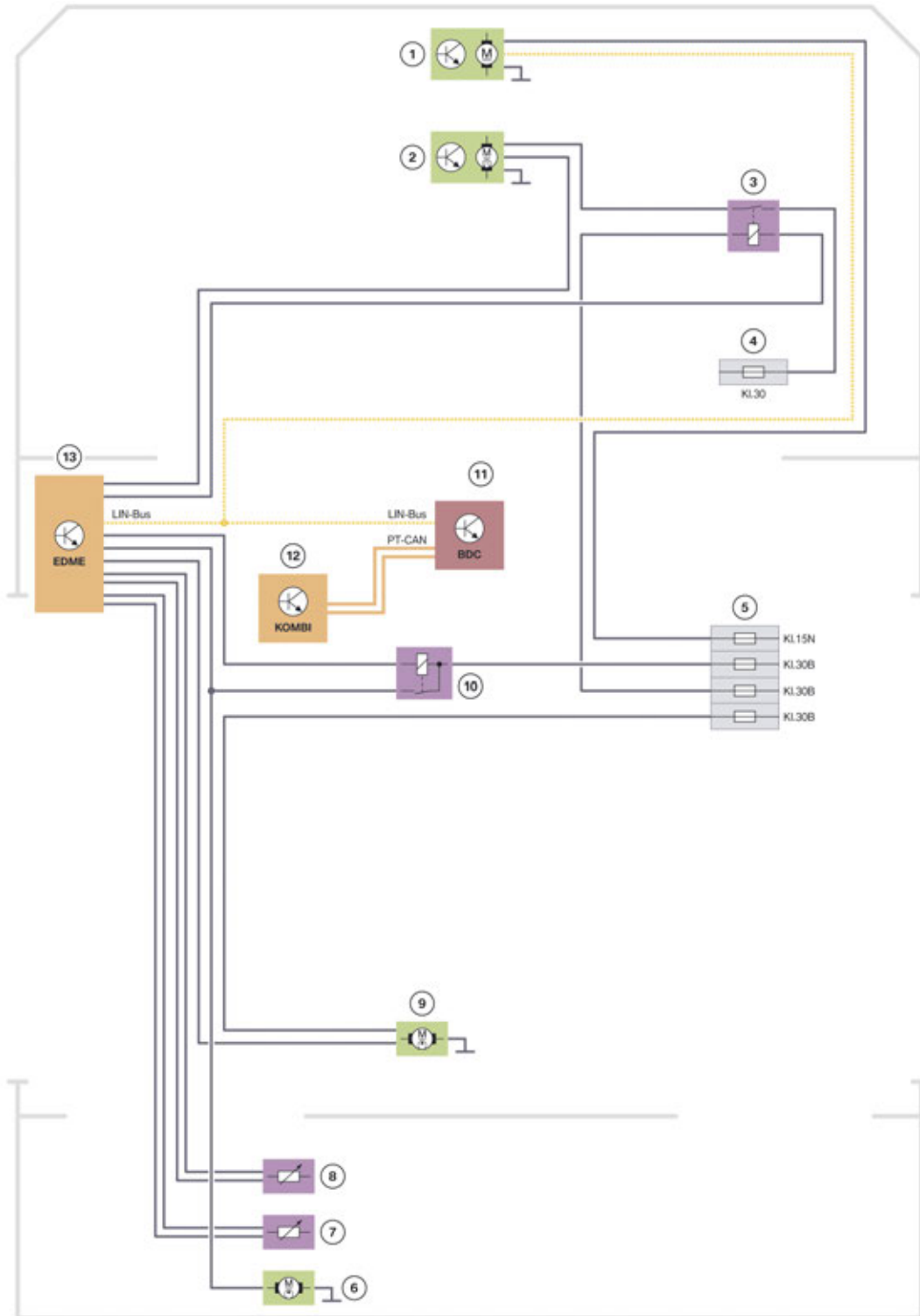
If the coolant temperature rises above 85° C, the additional coolant-to-coolant heat exchanger is integrated in the cooling circuit via the thermostat. The maximum flow rate in the cooling circuit of the W20 engine is 35 l/min, in the cooling circuit of the high-voltage system 17 l/min. At a maximum load of the combustion engine the coolant temperature in the outlet area of the cylinder head is approx. 95° C. With the additional heat exchanger it is possible to reduce the coolant temperature by approx. 10° C.

The coolant temperature is recorded using a coolant temperature sensor in the coolant duct at the cylinder head. If this temperature rises above a defined value, the driver is informed via the central information display. An intervention by the engine control RDME to reduce the engine performance or switch off the combustion engine is not effected.

W20 Engine

4. Cooling

4.3.1. System wiring diagram



TO12-1021

W20 engine, system wiring diagram, drive cooling with range extender

W20 Engine

4. Cooling

Index	Explanation
1	Electric motor for the automatic air flap control
2	Electric fan for the radiator
3	Relay for electric fan
4	Power distribution boxes
5	Distribution block
6	Electric fan in the engine compartment
7	Coolant temperature sensor at the electric fan
8	Coolant temperature sensor in the engine compartment
9	Electric coolant pump 80 W
10	Relay for electric fan, engine compartment
11	Body Domain Controller BDC
12	Instrument cluster
13	Electrical Digital Motor Electronics (EDME)

4.3.2. Temperature monitoring of the engine compartment

The combustion engine is encapsulated in order to keep the noise generation when the combustion engine is running as low as possible. In order to avoid the components in the engine compartment overheating, an electric fan is located in the rear-wheel drive near the drive unit of the vehicle. As soon as the W20 engine is started, the EDME also activates the electric fan. This runs permanently until the combustion engine is shut down again. Depending on the engine compartment temperature, which is measured using two temperature sensors in the rear-wheel drive, the fan can also run on for up to 11 minutes, also when the ignition is switched off. This way it is guaranteed that regardless of the operating condition of the vehicle no components are damaged as a result of excessive temperatures in the engine compartment.

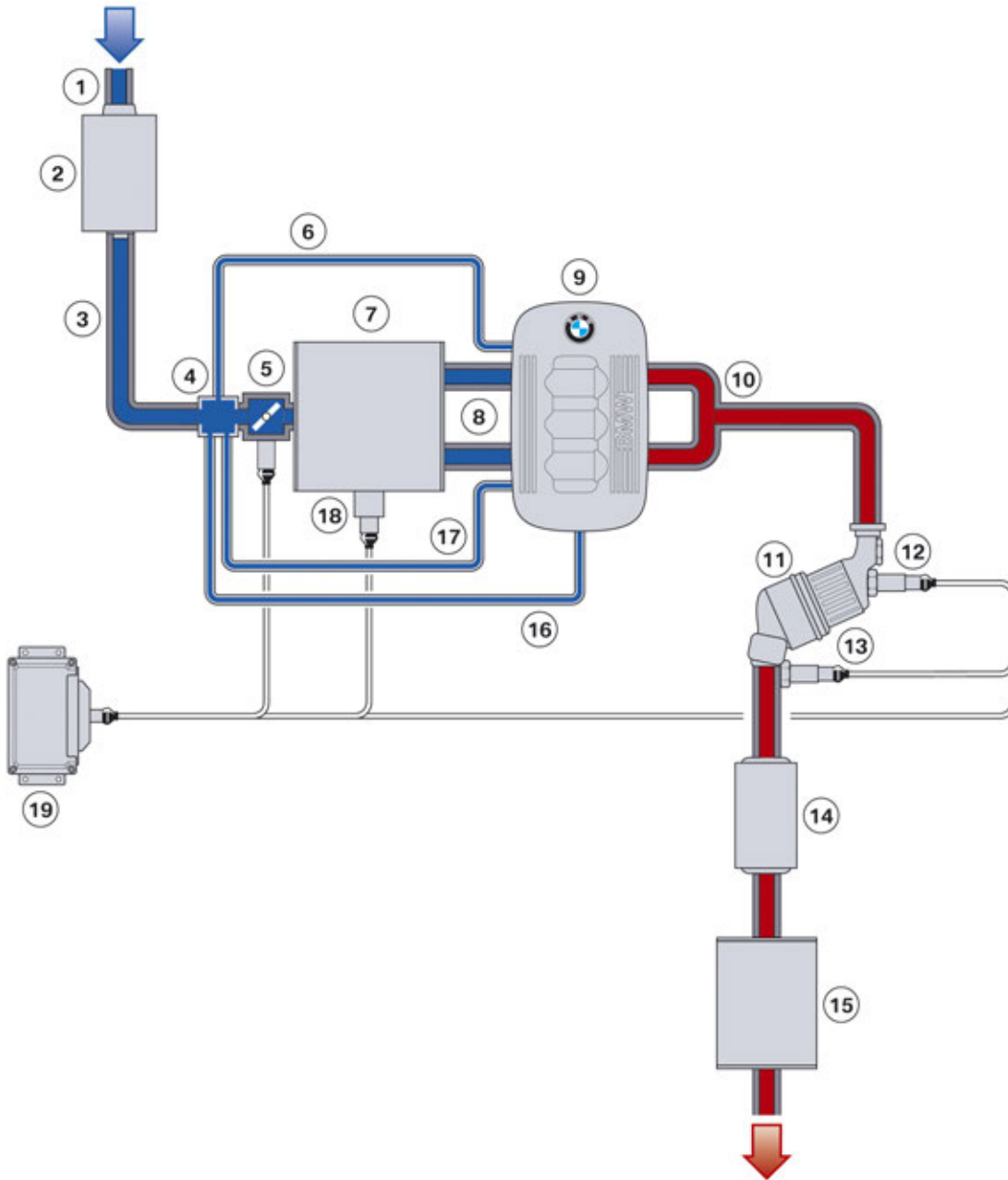


The combustion engine is switched off straight away during operation if excessive heat is identified by the two temperature sensors.

W20 Engine

5. Air Intake & Exhaust Emission Systems

5.1. System overview



TO13-0499

W20 engine, air intake and exhaust emission systems

Index	Explanation
1	Unfiltered air pipe
2	Intake silencer with air filter
3	Clean air pipe
4	Adapter

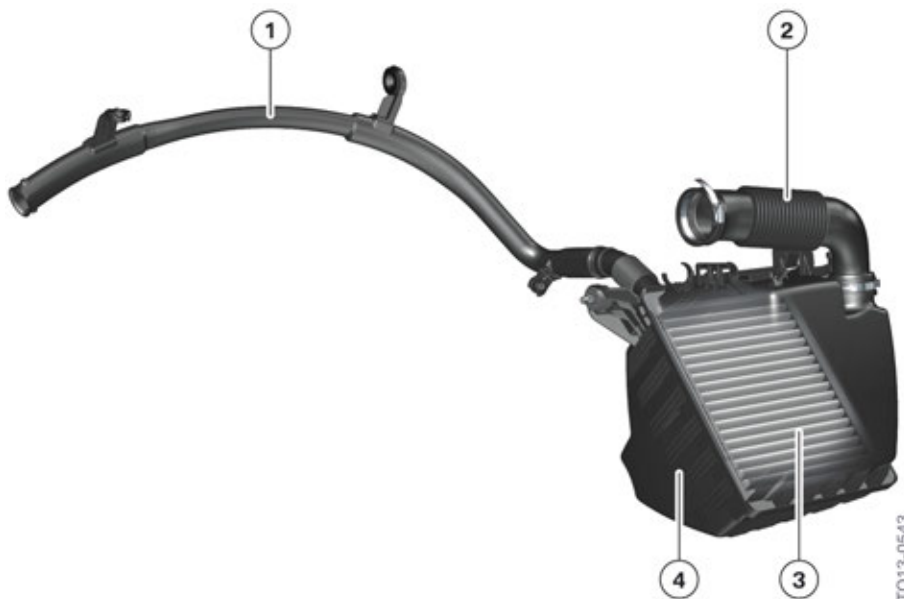
W20 Engine

5. Air Intake & Exhaust Emission Systems

Index	Explanation
5	Throttle valve
6	Turbulence line
7	Intake manifold
8	Intake neck
9	Combustion engine
10	Exhaust manifold
11	Catalytic converter
12	Oxygen sensor before catalytic converter, control sensor (LSU ADV)
13	Oxygen sensor after catalytic converter, monitoring sensor (LSF Xfour)
14	Decoupling element
15	Rear silencer
16	Ventilation line with non-return valve
17	Turbulence line
18	Air temperature and intake-manifold pressure sensor
19	Range Extender Digital Engine Electronics (RDME)

5.2. Air intake system

5.2.1. Intake silencer



W20 engine, intake silencer

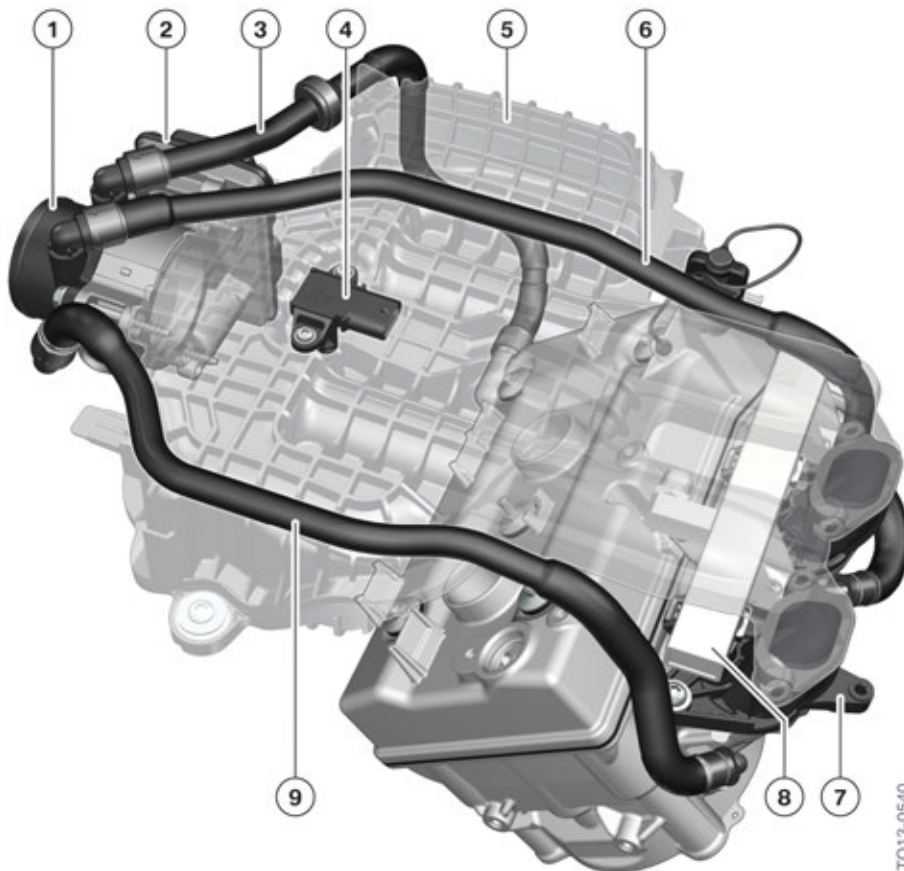
W20 Engine

5. Air Intake & Exhaust Emission Systems

Index	Explanation
1	Fresh-air duct
2	Clean air pipe
3	Air filter
4	Intake silencer

The two-piece intake silencer includes the air cleaner in the middle. This is made up of polyester fleece and is injected in a plastic frame. The housing halves of the intake silencer are firmly connected and can no longer be opened. A replacement of the air cleaner is not planned. Via a fresh-air duct, intake air reaches the clean air duct via the filter element. The intake silencer is stored in a disconnected state and includes the bracket for the RDME control unit in the upper area.

5.2.2. Differentiated air intake system with electronic throttle actuator



W20 engine, differentiated air intake system

W20 Engine

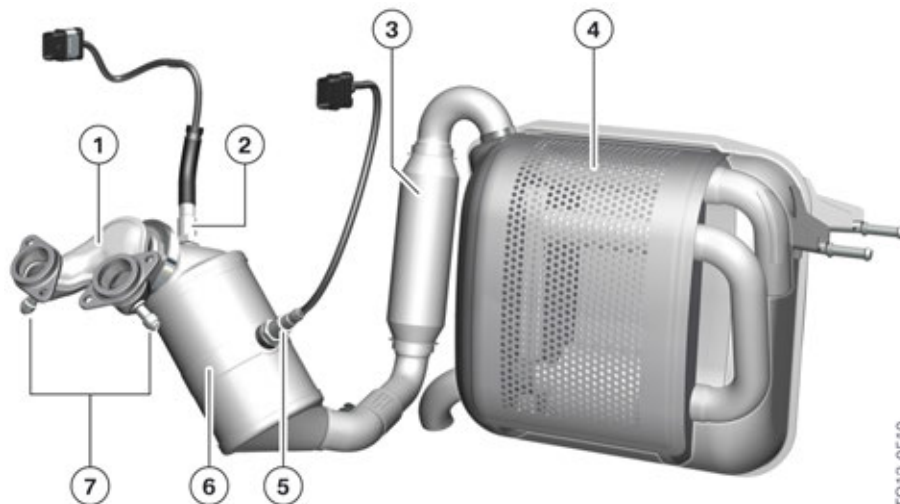
5. Air Intake & Exhaust Emission Systems

Index	Explanation
1	Adapter with three connections
2	Electronic throttle actuator
3	Ventilation line with non-return valve
4	Air temperature and intake-manifold pressure sensor
5	Intake manifold
6	Turbulence line
7	Intake neck
8	Fuel injection pipe with fuel injectors
9	Turbulence line

The differentiated air intake system is connected to the clean air pipe via the throttle valve by an additional adapter. At the adapter the turbulence line and the ventilation line with non-return valve are secured using snap fasteners. The turbulence lines generate a swirling effect as a result of the air flow upstream from the intake valve during the mixture preparation. The combustion becomes more efficient as a result. The function primarily has an effect in the partial load range as with a small throttle opening the vacuum in the intake pipe is greatest and thus a higher volumetric flow is achieved in the turbulence lines.

5.3. Exhaust emission system

5.3.1. Structure and function



W20 engine, exhaust system

TO13-0510

W20 Engine

5. Air Intake & Exhaust Emission Systems

Index	Explanation
1	Exhaust manifold
2	Oxygen sensor before catalytic converter, control sensor (LSU ADV)
3	Decoupling element
4	Rear silencer
5	Oxygen sensor after catalytic converter, monitoring sensor (LSF Xfour)
6	Catalytic converter
7	Connections, secondary air system (only US)

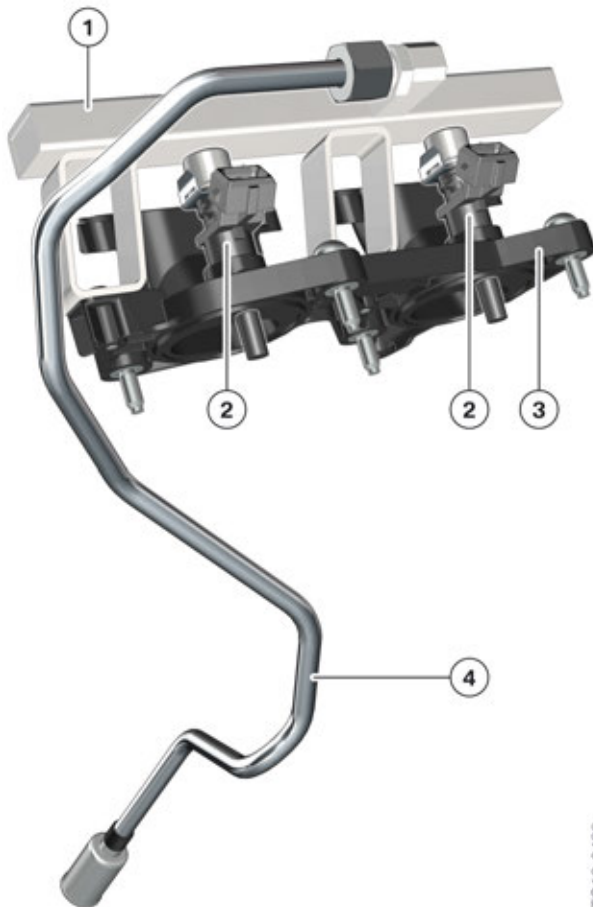
During the development of the individual components the aim was to reduce the arising noise level of the exhaust as much as possible. The heat development in the entire exhaust system should also be kept as low as possible through quick release of the exhaust gas. Due to narrow spatial conditions in the engine compartment the exhaust system was also developed with a very compact design. An air-gap-insulated exhaust manifold enables the catalytic converter near the engine to heat up quickly through minimal heat losses. The operating temperature of the catalytic converter is reached quicker after the engine cold start. A control sensor is located directly behind the exhaust manifold outlet. The monitoring sensor is positioned after the ceramic monolith. The rear silencer is connected using a decoupling element.

W20 Engine

6. Fuel Preparation

6.1. Overview

The following overview shows the fuel preparation system of the W20 engine. The fuel delivery line is screwed to the fuel injectors at the fuel injection pipe. The electrical solenoid valves are activated by the RDME.



TO13-0489

W20 engine, fuel preparation

Index	Explanation
1	Fuel injection pipe
2	Fuel injectors
3	Intake neck
4	Fuel delivery line



When working on the fuel system, it is essential to adhere to conditions of absolute cleanliness and to observe the work sequences described in the repair instructions. Even the slightest dirt contamination and damage to the screw connections of the fuel lines can cause leaks.

W20 Engine

6. Fuel Preparation

6.2. Fuel pump control

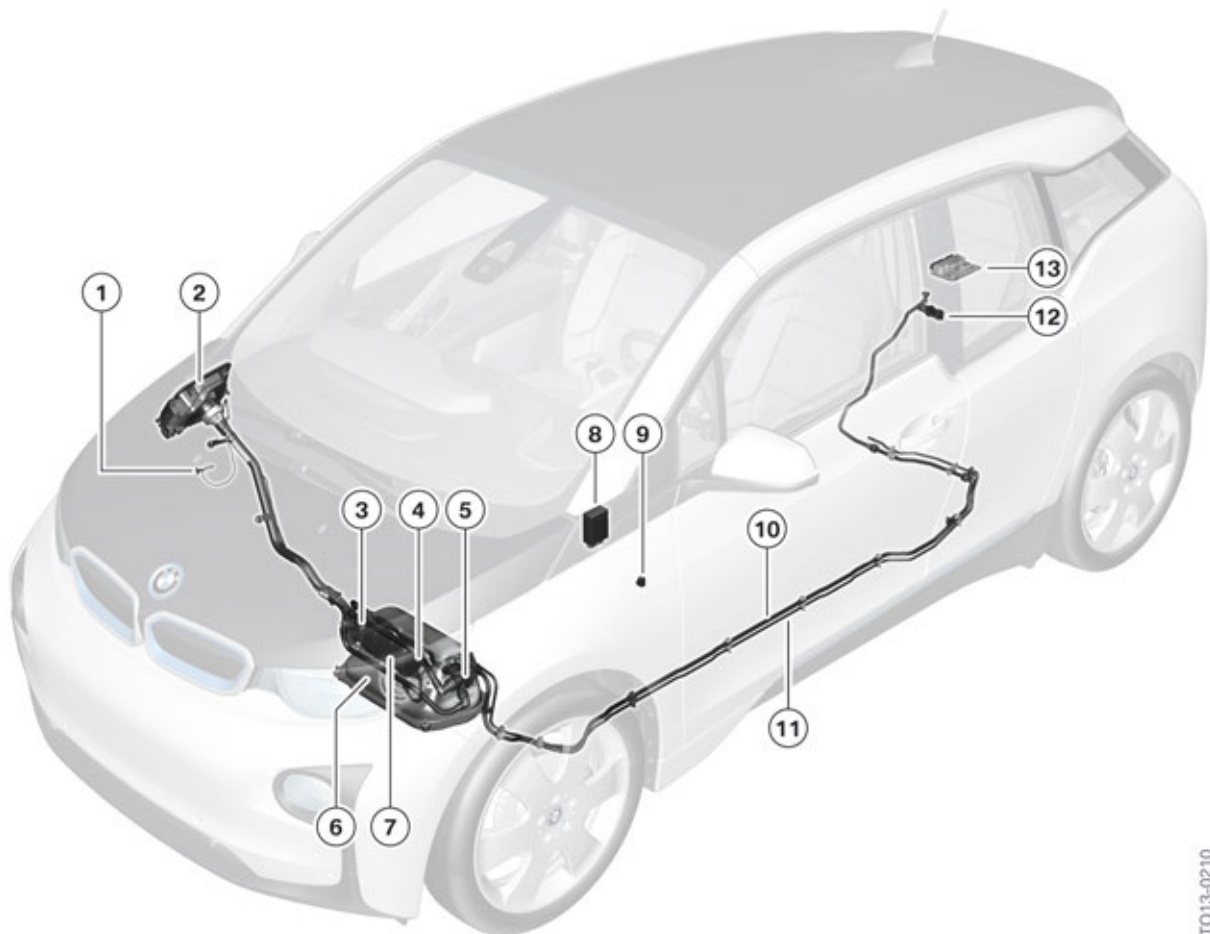
The fuel is delivered from the fuel tank through the electric fuel pump via the fuel delivery line at a maximum possible pressure of 5.9 bar to the fuel injector. The activation is effected via the RDME.

W20 Engine

7. Fuel Supply

For the operation of the range extender the vehicle is equipped with a pressurised fuel tank made from stainless steel. As a result during purely electric driving it is guaranteed that the gasoline fumes remain in the pressurised fuel tank. Only through the operation with a range extender is fresh air drawn in by the carbon canister for purging and the gasoline fumes are directed to the combustion chamber via the differentiated air intake system. The fuel tank capacity is 9 liters / 2.38 gallons with a 2 liter / .5 gallon fuel reserve.

7.1. Installation locations of the components



W20 engine, components of the fuel supply

Index	Explanation
1	Cable for emergency release of the fuel filler flap
2	Fuel filler flap with electrical lock
3	Fuel tank non-return valve (US version)
4	Connection for dust filter (US version)
5	Fuel tank isolation valve
6	Pressurised fuel tank made from stainless steel

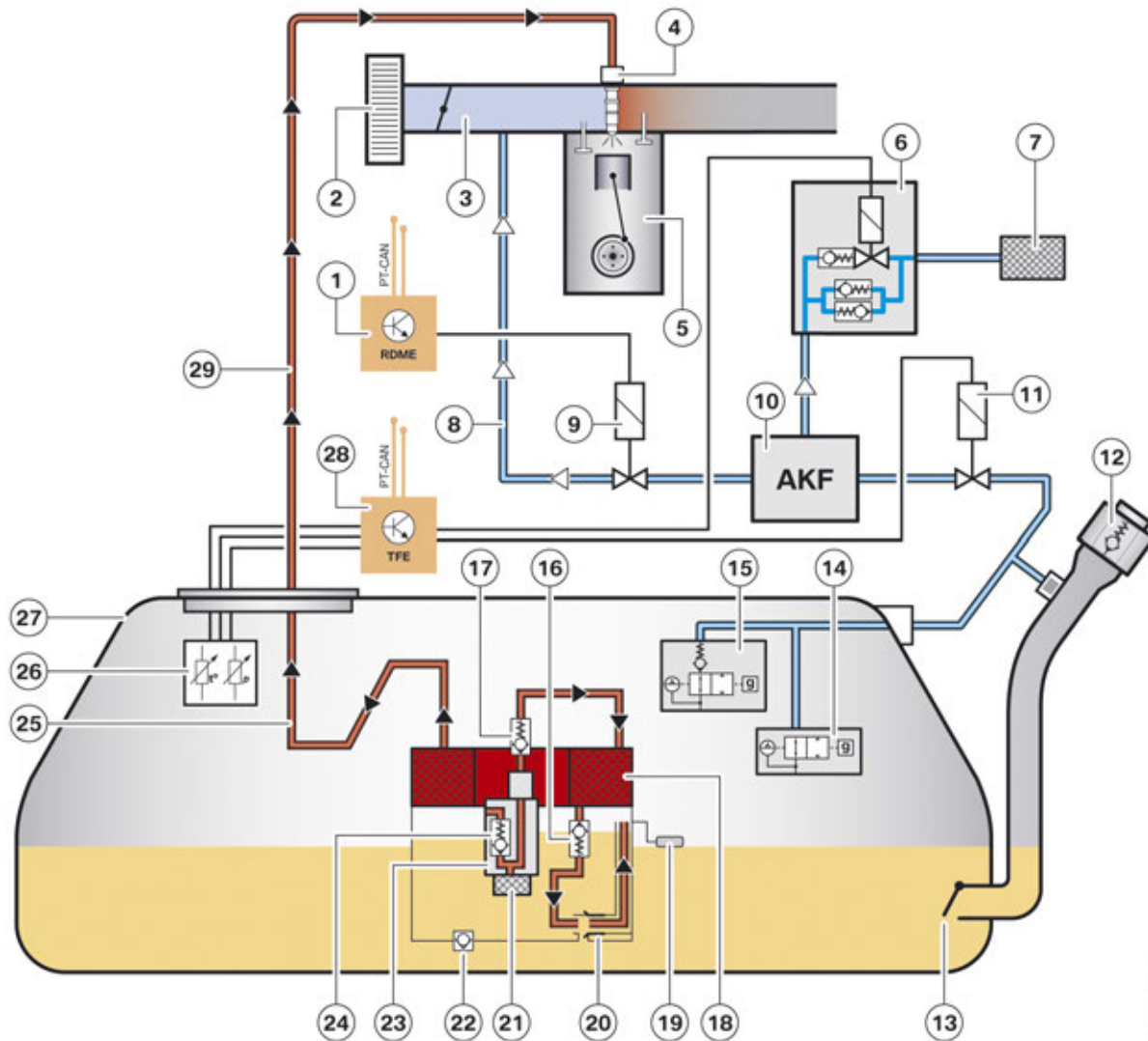
TO13-0210

W20 Engine

7. Fuel Supply

Index	Explanation
7	Carbon canister
8	Hybrid pressure refueling electronic control unit (TFE)
9	Tank button for opening the fuel filler flap
10	Purge air line
11	Feed line
12	Tank vent valve
13	Range Extender Digital Engine Electronics (RDME)

7.2. System overview



W20 engine, fuel supply, US version

W20 Engine

7. Fuel Supply

Index	Explanation
1	Range Extender Digital Engine Electronics (RDME)
2	Air filter
3	Intake manifold
4	Fuel injectors
5	Combustion engine
6	Fuel tank isolation valve, normally closed
7	Dust filter
8	Purge air line
9	Tank vent valve (TEV), normally closed
10	Carbon canister
11	Fuel tank non-return valve, normally open
12	Fuel filler cap with pressure relief valve (opening start at 450 mbar)
13	Non-return valve
14	Refueling ventilation valve
15	Service vent valve with overtank protection
16	Non-return valve
17	Non-return valve
18	Fuel filter
19	Lever sensor for fuel level
20	Suction jet pump
21	Suction strainer
22	First fill valve
23	Electric fuel pump (EKP)
24	Pressure-limiting valve
25	Feed line
26	Pressure temperature sensor
27	Pressurised fuel tank made from stainless steel
28	Hybrid pressure refueling electronic control unit (TFE)
29	Feed line

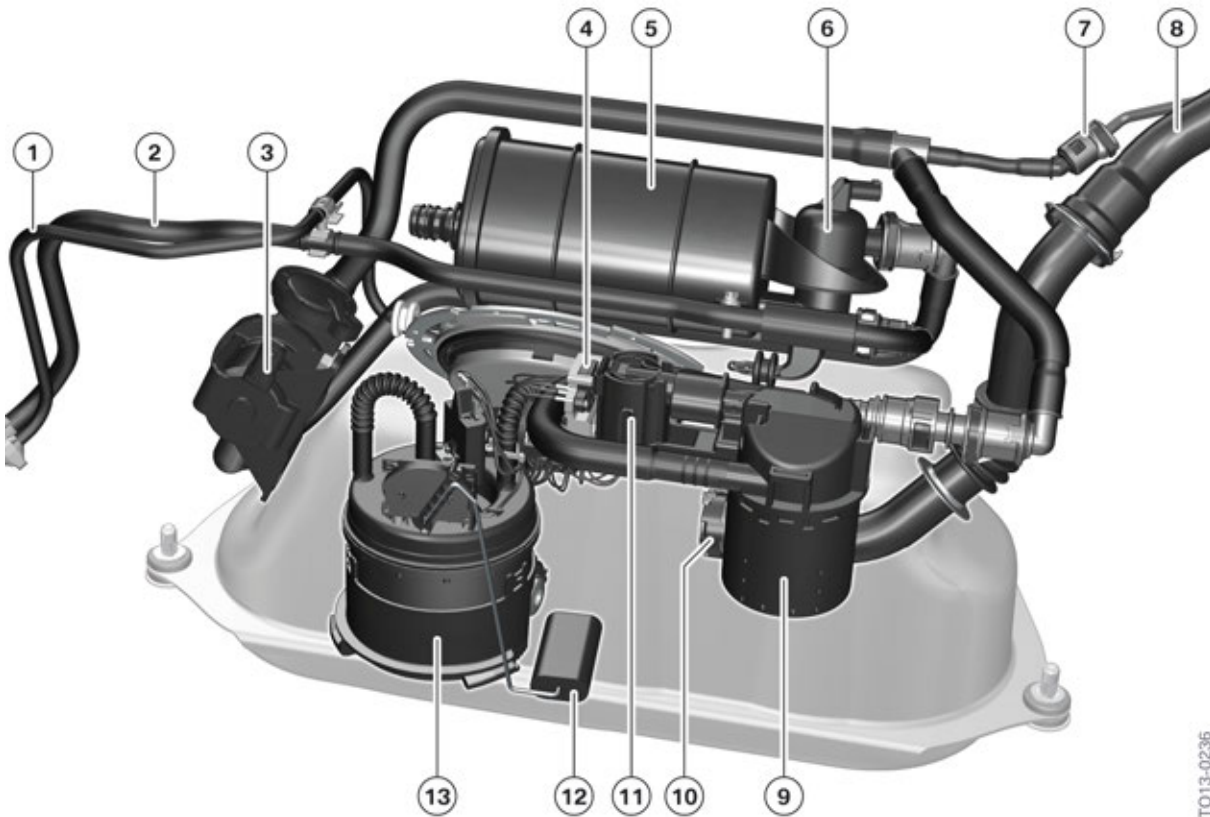
The components in the inside of the tank are not new. The additive pump is switched on or off via a relay by the RDME control unit. The fuel pressure in the feed line is approx. 5 bar and is regulated at this level via a pressure limiting valve in the inside of the additive pump. The two non-return valves (16, 17) ensure that the pressure is maintained in the feed line and the line does not empty.

W20 Engine

7. Fuel Supply

7.3. Fuel tank

The electric fuel pump with a lever sensor is integrated in the newly formed stainless steel tank, which determines the fuel level. In addition to the filling valve and the service vent valve, the pressure temperature sensor can also be found in the tank.



TO13-0236

W20 engine, components of fuel supply, European version

Index	Explanation
1	Feed line
2	Purge air line
3	Fuel tank isolation valve
4	Pressure temperature sensor
5	Carbon canister
6	Fuel tank non-return valve
7	Tank ventilation line
8	Fuel filler neck
9	Refueling ventilation valve

W20 Engine

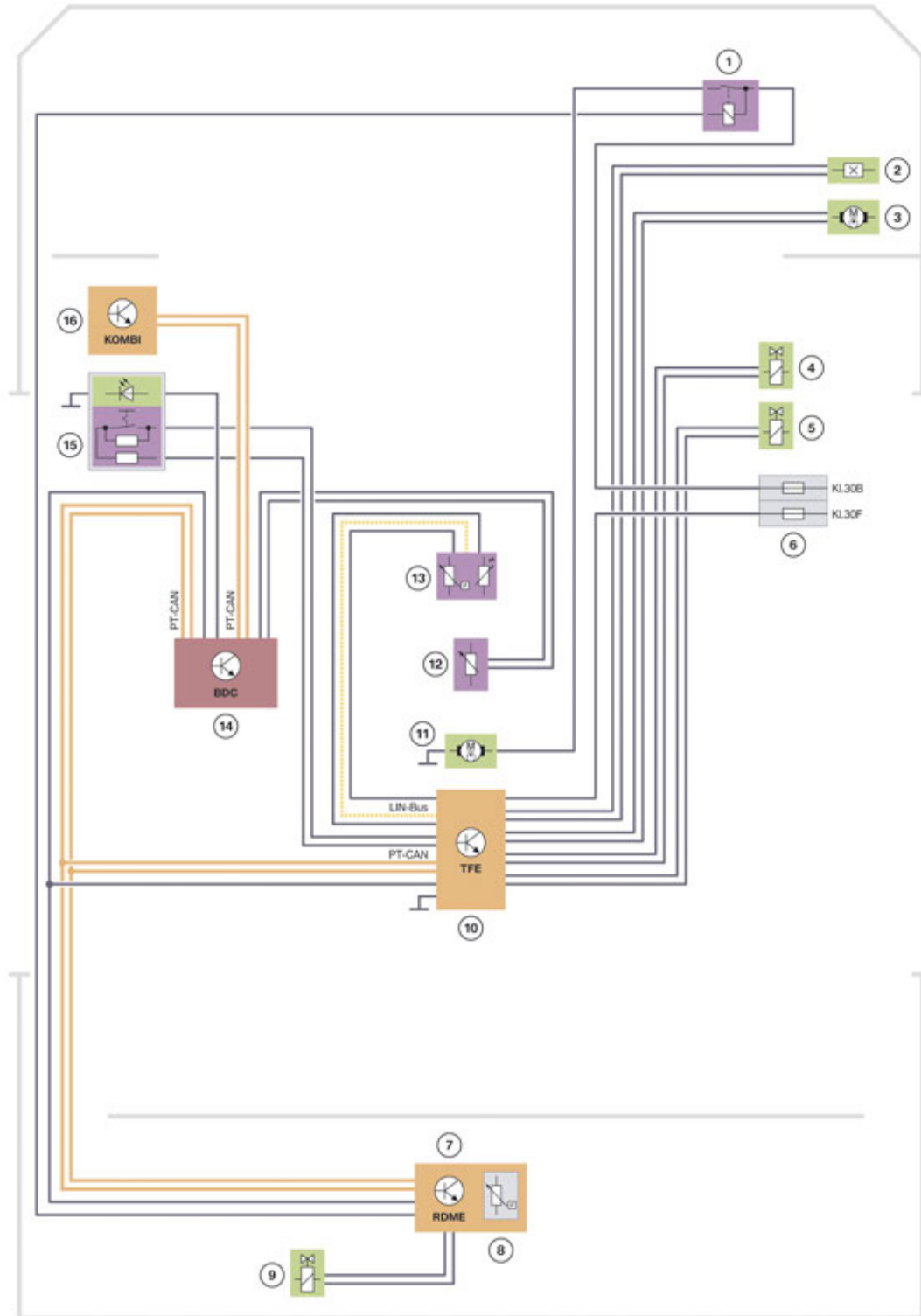
7. Fuel Supply

Index	Explanation
10	Non-return valve
11	Service vent valve with over fill protection
12	Lever sensor
13	Electric fuel pump (EKP)

W20 Engine

7. Fuel Supply

7.4. System wiring diagram



TO13-0208

W20 engine, system wiring diagram for fuel supply

W20 Engine

7. Fuel Supply

Index	Explanation
1	Relay, electric fuel pump
2	Sensor for the position of the fuel filler flap
3	Actuator drive for locking the fuel filler flap
4	Fuel tank isolation valve
5	Fuel tank non-return valve
6	Distribution block
7	Range Extender Digital Engine Electronics (RDME)
8	Ambient pressure sensor
9	Tank vent valve
10	Hybrid pressure refueling electronic control unit (TFE)
11	Electric fuel pump EKP
12	Lever sensor for fuel level
13	Pressure temperature sensor in the fuel tank
14	Body Domain Controller (BDC)
15	Button with lighting for refuelling
16	Instrument cluster

7.5. Refuelling

The pressurised fuel tank must be bled for refuelling. In this way it is guaranteed that the tank request is indicated to the electronics by a button in the passenger compartment of the vehicle. The hybrid pressure refueling electronic control unit TFE monitors the current operating condition via a pressure temperature sensor in the fuel tank and then controls the pressure reduction by opening the fuel tank isolation valve. The clean gasoline fumes are released into the environment via the carbon canister. The actuator drive for locking the fuel filler flap is activated and the fuel filler flap with fuel filler cap can be opened manually.



Before repair work on the fuel supply the refueling procedure must be started so that the pressure in the fuel tank can be released. Leave the fuel filler cap open in order to avoid pressure building up again.

At the same time, the driver receives the status of the tank readiness displayed in the instrument cluster and in the central information display. If the fuel filler flap is not opened within 10 minutes after the fuel filler cap has been released, it is automatically locked again. The position of the fuel filler flap is identified using a hall effect sensor.

After the refueling procedure and the fuel filler cap is closed the fuel filler flap is locked again via the hybrid pressure refueling electronic control unit and the fuel tank isolation valve closed. The displays in the instrument cluster and central information display are removed.

W20 Engine

7. Fuel Supply



No charging and refueling at the same time! When the charging cable is inserted do not initiate a refueling procedure and keep a safe distance from highly flammable materials. Otherwise, in the event of incorrect connection or removal of the charging cable there is a risk of personal injury or material damage by burning fuel for example.

7.6. Tank leak diagnosis

After the shutdown phase of the vehicle (terminal 15 OFF) a test of the tank leak diagnosis is initiated by the hybrid pressure refueling electronic control unit TFE control unit. This is carried out over a period of approx. 6 hours. In this period the temperature and the pressure in the stainless steel tank are measured. As the pressure changes depending on the temperature, it is possible to identify a pressure loss in the fuel tank using a stored characteristic curve in the control unit. A prerequisite is therefore that the temperature changes over the test period. If this does not happen no results can be concluded.

The ambient air pressure is also included in the calculation of the characteristic curve. An internal sensor in the RDME control unit determines this value and makes this information available to the hybrid pressure refueling electronic control unit via the PT-CAN.

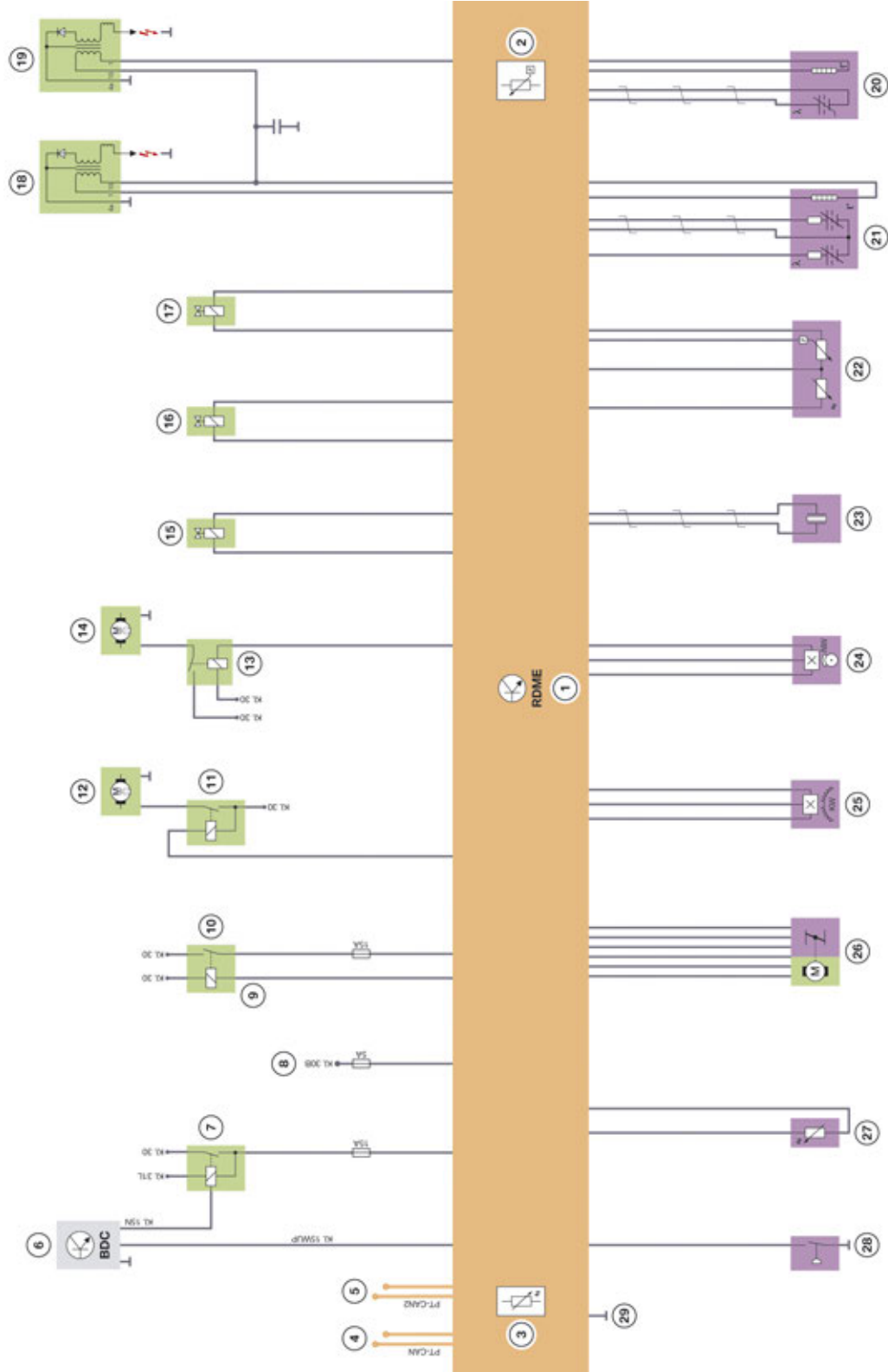
If during the test phase the vehicle is started no result can be evaluated. Each time after the shutdown phase of the vehicle the tank leak diagnosis restarts via the TFE control unit.

Following a comparison of the measured pressure readings with the saved characteristic curve in the control unit, information is transmitted to the RDME via the PT-CAN in the case of a deviation from the hybrid pressure refueling electronic control unit. A corresponding entry is set in the control unit. This happens as soon as the ignition of the vehicle is switched on.

W20 Engine

8. Engine Electrical System

8.1. Overview



W20 engine, RDME system wiring diagram

W20 Engine

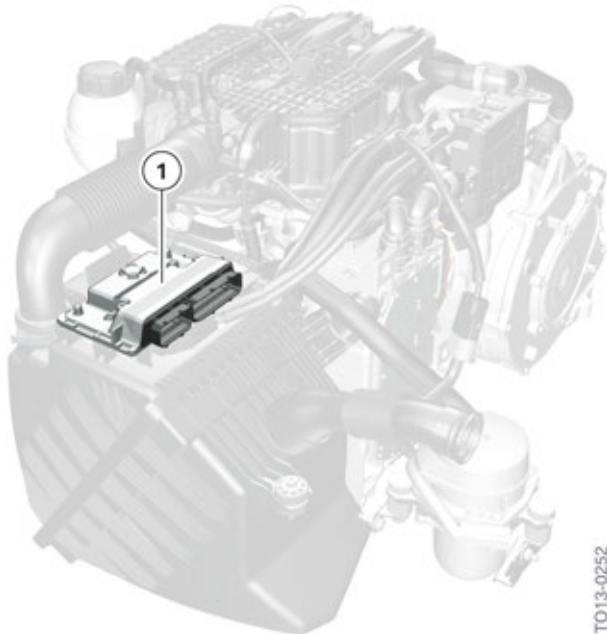
8. Engine Electrical System

Index	Explanation
1	Range Extender Digital Engine Electronics
2	Internal ambient pressure sensor
3	Internal temperature sensor
4	PT-CAN
5	PT-CAN2
6	Body Domain Controller (BDC)
7	Input, voltage supply via relay, terminal 15 N (ignition)
8	Input, voltage supply via terminal 30 b
9	Switch output, relay, ignition and fuel injection
10	Input, voltage supply, ignition and fuel injection
11	Switch output, relay, electric fuel pump
12	Electric fuel pump (EKP)
13	Switch output, relay, secondary air pump
14	Secondary air pump
15	Tank vent valve
16	Fuel injector 1
17	Fuel injector 2
18	Ignition coil 1
19	Ignition coil 2
20	Oxygen sensor LSF Xfour
21	Oxygen sensor LSU ADV
22	Air temperature and intake-manifold pressure sensor after throttle valve
23	Knock sensor
24	Camshaft sensor
25	Crankshaft sensor
26	Throttle valve
27	Engine temperature, coolant
28	Oil pressure switch
29	Earth

W20 Engine

8. Engine Electrical System

8.2. Engine control unit



TO13-0252

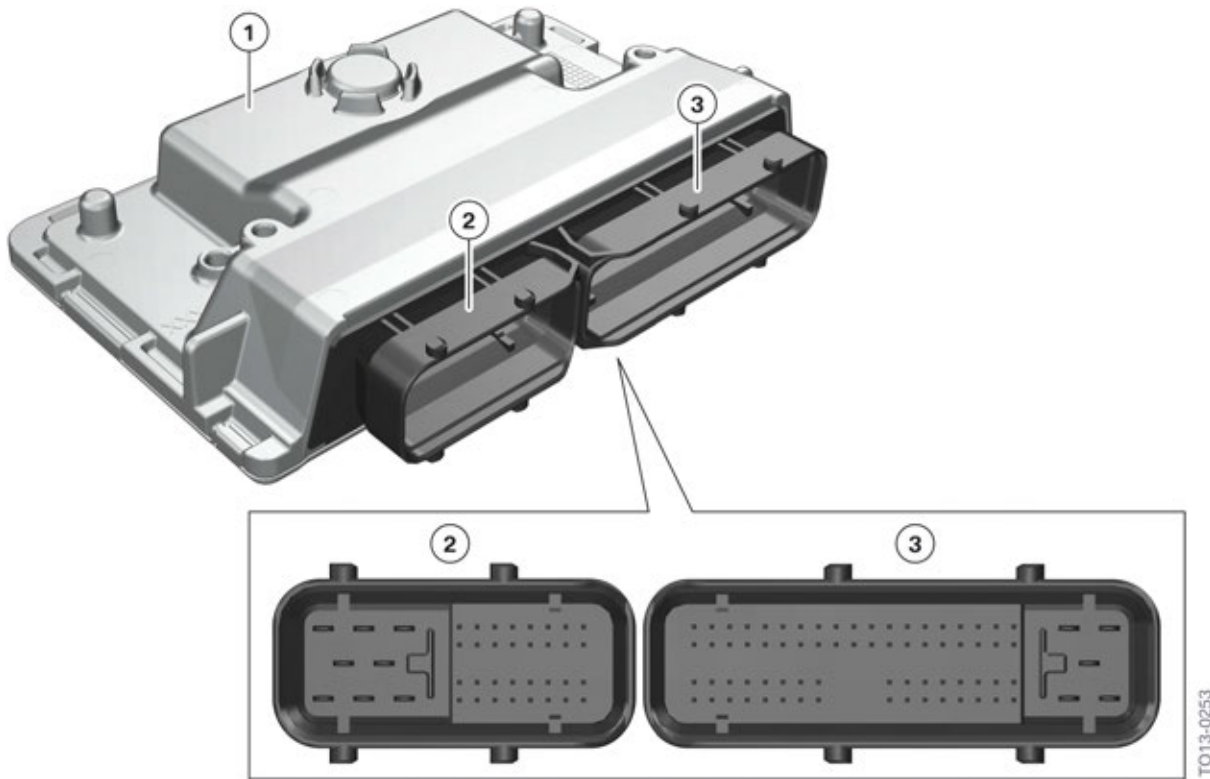
W20 engine, Range Extender Digital Engine Electronics RDME

Index	Explanation
1	RDME control unit

The RDME engine electronics controls the entire engine running of the two cylinder using state-of-the-art microcontrollers and with a fully sequential and cylinder-specific fuel injection and ignition ensures low fuel consumption and compliance with the current exhaust emission standards. The control unit is secured above the intake silencer and can be reached via the service flap at the rear of the vehicle.

W20 Engine

8. Engine Electrical System



W20 engine, PIB, RDME control unit

Index	Explanation
1	Control unit, Range Extender Digital Engine Electronics (RDME)
2	Module 2, 40 pins
3	Module 1, 81 pins

Two modules combine the control unit to the wiring harness of the vehicle. Module 2 with the 40 pins includes the connections for the fuel injectors, ignition coils, the intake air temperature and pressure sensor and the knock sensor. Module 1 with the 81 pins assumes the remainder of the sensors and actuators. The printed circuit board in the RDME control unit accommodates two sensors: a temperature sensor and an ambient pressure sensor. The temperature sensor is used to monitor the temperature of the components in the RDME control unit. The ambient pressure is required for calculating the mixture composition.

8.2.1. Overall function

The Range Extender Digital Engine Electronics RDME is the computing and switching center of the engine control. Sensors on the engine and the vehicle deliver the input signals. The signals for activating the actuators are calculated from the input signals, the setpoint values calculated using a computing model in the DME control unit and the stored characteristic maps. The RDME control unit activates the actuators directly or via relays.

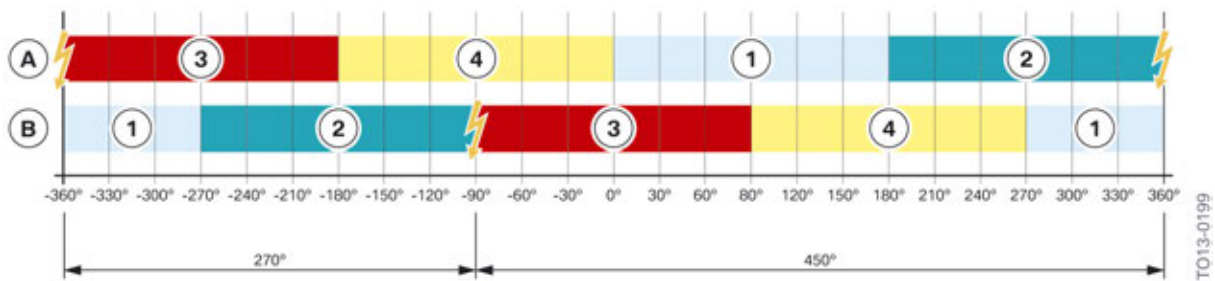
The RDME control unit is woken up via the wake-up line (terminal 15 Wake up) by the Body Domain Controller (BDC).

W20 Engine

8. Engine Electrical System

The engine control takes into consideration a variety of factors. The basis of the control is the amount of air drawn in, which is defined indirectly via the intake pipe vacuum and the engine speed. The engine control establishes individual coordinated values for the fuel injection rate and the ignition point from additional engine and ambient parameters such as coolant temperature, intake air temperature, throttle valve position and ambient air pressure, together with stored characteristic maps and correction functions.

An unequal firing interval from 450° kW and 270° kW results from the crankpin offset. The different work cycle of cylinders 1 and 2, as well as the resulting firing interval, can be seen in the following graphic.



W20 engine, ignition point and firing interval

Index	Explanation
A	Cylinder 1
B	Cylinder 2
1	"Intake" work cycle
2	"Compression" work cycle
3	"Power" work cycle
4	"Exhaust" work cycle

The after-run starts after terminal 15 OFF. The adaptation values are stored during the after-run. The RDME control unit uses a bus signal to indicate its readiness to "go to sleep". When all the participating control units have signalled their readiness to "go to sleep", the bus master outputs a bus signal and the control units terminate communication five seconds later.

W20 Engine

9. Operating Strategy in the BMW I01

9.1. Overview

The operating strategy describes the interaction of the drive components in the vehicle. In this chapter details are provided on the behavior of the W20 engine. This includes when and how the combustion engine is operated in the complete system.

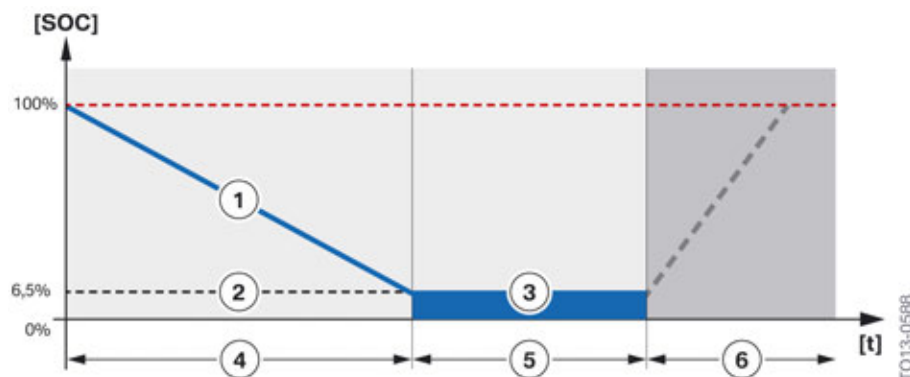
The BMW I01 is equipped with a purely electric drive system. The energy required for the operation of the electrical machine is stored in the high-voltage battery. The range of the vehicle is therefore limited. The optional range extender powers an e-machine, where current is supplied to the high-voltage intermediate circuit. Depending on requirements the current flows directly to the motor of the electrical machine or to the high-voltage battery unit. The aim is to keep the state of charge (SOC) at a constant level. The range of the vehicle can thus be extended.

The operating strategy is shown in the following graphic. The available power and thus the state of charge of the high-voltage battery is defined between 0 and 100 %. It is important to note that these are relative values and not absolute values. When driving without a combustion engine (4) the energy required is taken from the high-voltage battery. The state of charge (1) drops continuously and reaches the switch-on threshold (2). The combustion engine is now started and powers an e-machine. Depending on the driving style it is now possible to keep the state of charge of the high-voltage battery constant or even increase it (3). If the state of charge rises again above the switch-on threshold (2), the combustion engine is switched off.

The driving style has a direct influence on the discharge of the high-voltage battery and thus also on the range. A comparison of the performance data at full load should highlight this:

- 25 kW / 34 hp mechanical output power of the combustion engine
- 23.5 kW electrical output power of the e-machine
- 125 kW power diversion by the electrical machine.

Using this example at full load it is clear that this driving style leads to a further drop in the state of charge of the high-voltage battery. The output power of the combustion engine and thus the e-machine is not sufficient to keep the state of charge of the high-voltage constant.



W20 engine, operating strategy

W20 Engine

9. Operating Strategy in the BMW I01

Index	Explanation
1	State of charge of the high-voltage battery
2	Switch-on threshold, SOC 6.5% relative
3	Internal combustion engine running, SOC 6.5 - 0 % relative
4	Electrical driving without combustion engine
5	Electrical driving with combustion engine
6	Charging, external

9.2. Influencing factors

During the development of the BMW I01 the objective was to eliminate interference noises by the combustion engine and, at the same time, generate a sound pattern typical of the brand. This combined with a comfortable extension of the range. For this reason the output power and thus the speed of the range extender are influenced by various parameters. On the one hand, these are defined by the acoustics and range strategy, and, on the other hand, the ambient temperature also has a significant influence on the output power.

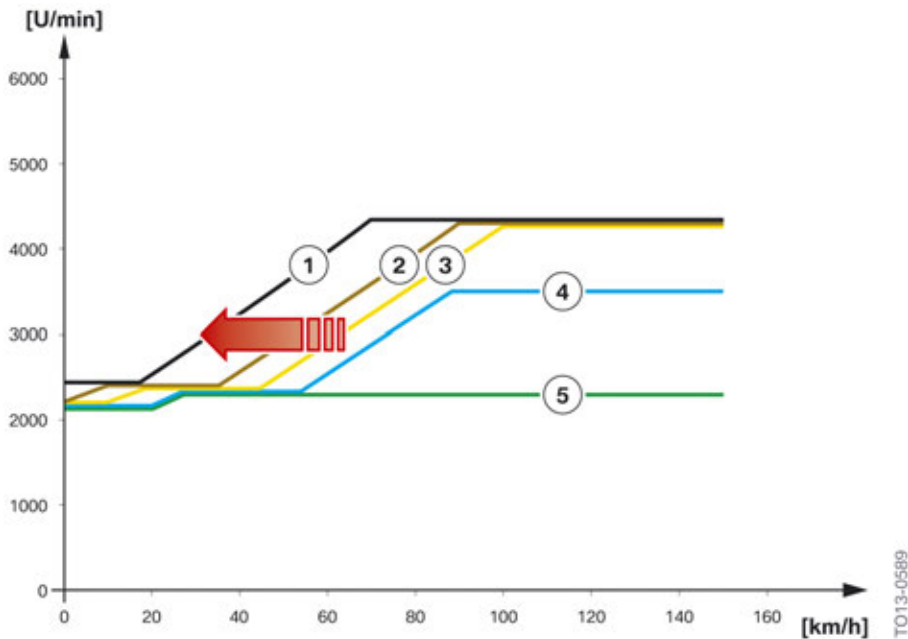
In order to bring the combustion engine and the catalytic converter to operating temperature, the combustion engine is operated at a speed of 2,200 rpm - 2,400 rpm during the warm-up phase (5). This is dependent on the speed driven and, at the same time, represents the idle speed of the combustion engine. The period for this warm-up phase is roughly 360 seconds depending on the ambient temperature.

The speed varies accordingly between 2,200 rpm and 4,300 rpm and also the output power of the combustion engine depending on the speed driven and the state of charge of the high-voltage battery. The resulting acoustics of the combustion engine are regulated conveniently by controlling the speed subject to the speed driven. In order to extend the range the engine speed is also influenced by the state of charge of the high-voltage battery.

The following graphic highlights the different operating conditions. If we now take a look at the blue line (5), which shows the engine speed range for the state of charge from 6.5 – 3.5 %. At a speed of 50 km/h the combustion engine is operated at a speed of 2,400 rpm. If the state of charge of the high-voltage battery drops, then the speed characteristic curve in the diagram moves to the left with a simultaneous increase of the maximum speed. Depending on the speed drive the speed of the combustion engine is increased earlier. More energy is made available to the high-voltage system.

W20 Engine

9. Operating Strategy in the BMW I01



W20 engine, acoustics and range strategy

Index	Explanation
1	Speed characteristic curve, SOC 0.7 %
2	Speed characteristic curve, SOC 1.5 %
3	Speed characteristic curve, SOC 2.5 %
4	Speed characteristic curve, SOC 6.5 - 3.5 %
5	Speed characteristic curve, warm-up phase

The dependence of the output power on engine speed and state of charge of the high-voltage battery was shown. Depending on the driving style and ambient temperature, different thermal conditions arise in the engine compartment, which also have to be considered for the control of the range extender. Therefore, the performance of the combustion engine is also influenced by the measured values of the outside temperature sensor. This is referred to as a thermal operating strategy. At extreme ambient temperatures the output power and the speed are reduced via a temperature model in the engine control unit RDME. As described in chapter 4.3.2, the engine compartment temperature is measured and monitored using two sensors and in extreme cases the combustion engine is switched off.

9.3. Automatic engine start/stop function

The combustion engine also has an automatic engine start-stop function. This function is not available during the warm-up phase. To activate the automatic engine start-stop function the presence of the driver must be detected using the seat belt and door contact. As long as the seat belt is inserted and the door is closed, the driver is considered present and the range extender is operated with automatic engine start-stop function.

The combustion engine is switched off under the following conditions:

W20 Engine

9. Operating Strategy in the BMW I01

- SOC 3.5 - 6.5%
- Speed < 10 km/h / 6 mph

If the driving speed is greater than 20 km/h / 12 mph, the combustion engine is restarted.

During the warm-up phase of the combustion engine or if the state of charge drops below 3.5% the automatic engine start-stop function is deactivated.

9.4. Automatic service

After a period of roughly eight weeks the combustion engine is automatically started. The identification of the standstill time is effected via the EDME control unit. An automatic start is required to guarantee the operational reliability of the range extender.

The process is indicated to the driver via a Check Control message during driving. The duration of the engine running is dependent on the starting temperature of the combustion engine. The driver is informed about the duration of the service via a time bar in the central information display. If the service of the range extender is carried out at an unfavorable time, this can be stopped by pressing the START-STOP button.

The following prerequisite must be satisfied so that the combustion engine is started:

- State of charge of the high-voltage battery < 75%
- Fuel tank content > 0.8 l
- No fault code entry in the RDME control unit.

W20 Engine

10. Service

An intelligent service already starts in the vehicle. This is why the maintenance system Condition Based Service CBS is also used in the I01. The instrument cluster in the cockpit automatically provides information in advance about what servicing must be performed.

So that the combustion engine cannot be easily started, it was necessary to develop special test operations for the service.

In order to be able to perform an exhaust-gas test in vehicles with range extender, there is the option to start the combustion engine by following a sequence of certain activities.

The "Service Start" was also developed for the diagnosis system, especially for troubleshooting at the vehicle. You find out more about this in the following sub chapters.

10.1. Exhaust-gas test mode

It is necessary to start the combustion engine for an exhaust-gas test in the BMW I01 with range extender. This is made possible by a certain operating sequence:

- Tailgate is open
- Switch on ignition and engage drive position "P" (without braking)
- Press and hold down the accelerator pedal within 60 seconds
- Press the brake three times within 20 seconds and hold
- Release the accelerator pedal and press the START-STOP button when the brake is actuated
- The combustion engine starts if the SOC of the high-voltage battery is less than 75 %.

As a Check Control message the status "Exhaust-gas test mode activated" is output when the combustion engine is running. The empty run point is automatically approached during the warm-up phase. Using the pedal sensor position two speed points of the combustion engine are selected for the measurement.

The "Exhaust-gas test" mode is automatically ended:

- after 20 minutes
- or at the start of the journey
- or by switching off the ignition.

10.2. Service Start

The diagnosis system provides a variety of options to Service. In the diagnosis interface ISTA (Integrated Service Technical Application) it is possible to select the service function "Start range extender". The combustion engine in the BMW I01 can be started and stopped for diagnosis purposes via the diagnosis system. Another selection in the service function "Start range extender" is the activation of different speeds.

W20 Engine

10. Service

10.3. Maintenance work

As the combustion engine in the BMW I01 is not permanently used, the servicing is reduced to a minimum. Engine oil with filter is only required after a time interval of 10,000 miles / 12 months or depending on the operating hours of the combustion engine. The operating hours are recorded in the EDME control unit.



During an oil change care should be exercised to ensure no oil is spilled when filling. A suitable funnel must be used. The repair instructions must be followed.

2.6 liters of oil is the capacity of the W20 engine.



Bayerische Motorenwerke Aktiengesellschaft
Qualifizierung und Training
Röntgenstraße 7
85716 Unterschleißheim, Germany